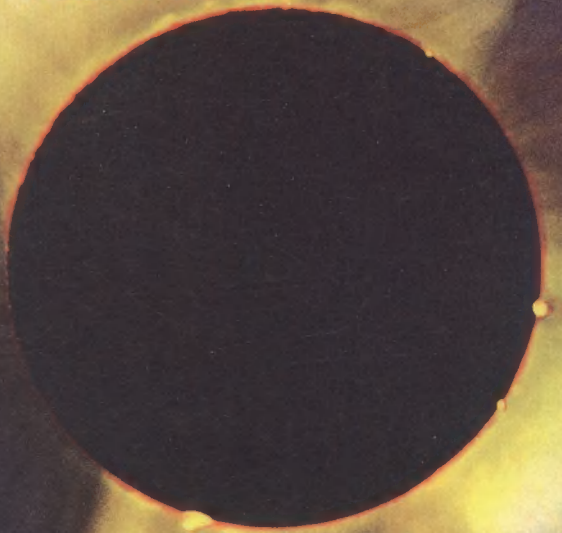
SCIENCE DIGEST

JUNE 1968 • 50 CENTS ICD

5 WAYS THE WORLD MAY END

Death of the sun • Supernova shock
Asteroid collision • Return of the moon
Meteoric storm

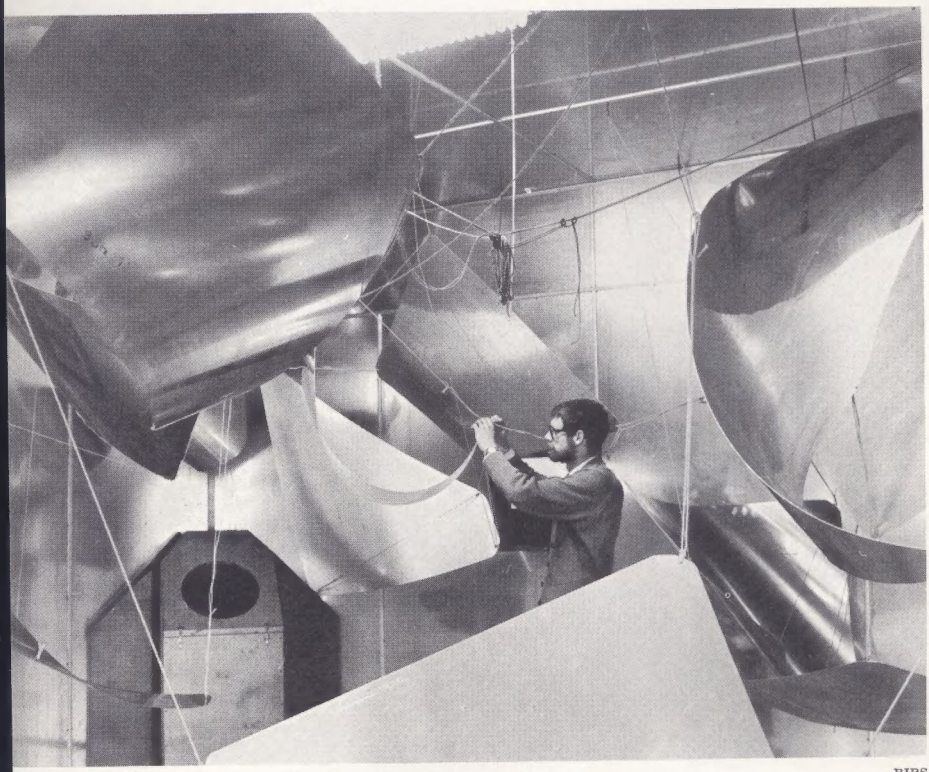


New clues to super civilizations in space

Itching: its causes; what to do about it

Life on board a nuclear submarine

EARTH SCIENCE SPECIAL:
What's happening to our world?



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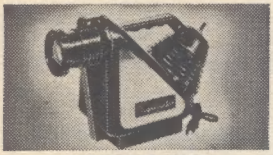

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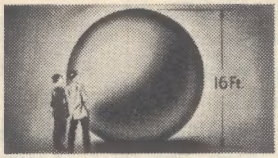

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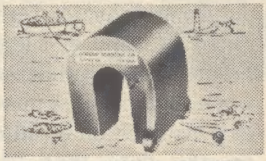

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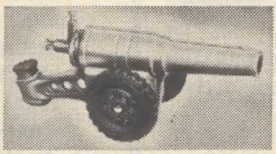

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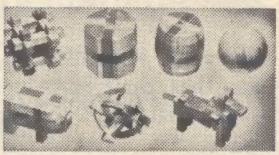

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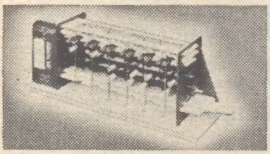

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PEOPLE have been forecasting Doomsday for centuries. Within my memory there have been three well-publicized occasions when some cultist managed to collect his flock on a hilltop at dawn—on the date that had been "revealed" to him—confident that they would be swept to Heaven in chariots while the world ended below. One such prophet drew a crowd of thousands. When chariots failed to

THIS MONTH

arrive on schedule, his explanation was that they had, indeed, arrived —in spirit—and that his flock was "saved."

Who can say he was a liar?

In a more rational vein, astronomers have long known that cosmic machinery makes Doomsday certain. Bruce Frisch's article on page 8 explains in fascinating detail the five ways it can happen. When?

Well, barring collisions with asteroids and meteorites, the sun (most likely destroyer) is good for 20 billion years. Officials at the Hayden Planetarium in New York, where a show on the subject was given, love to recall the aged lady spectator who came up to the narrator after a performance and asked, "How many years before the sun blows up?"

"Twenty billion," said the man.

"Thank Heavens!" replied the old gal with a sigh of huge relief. "I thought you said 20 *million*."

—RFD

SCIENCE

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Ancients thought eclipses meant the end of the sun; hence of their world. If the astronomy was off, the intuition was sound. See page 8. The white light photo of the eclipse on our cover, taken by Dr. Gordon Newkirk of the National Center for Atmospheric Research, is the first single exposure to show the fine structure of both near and far corona. Colors were added by our artist for visual effect.

DIGEST®

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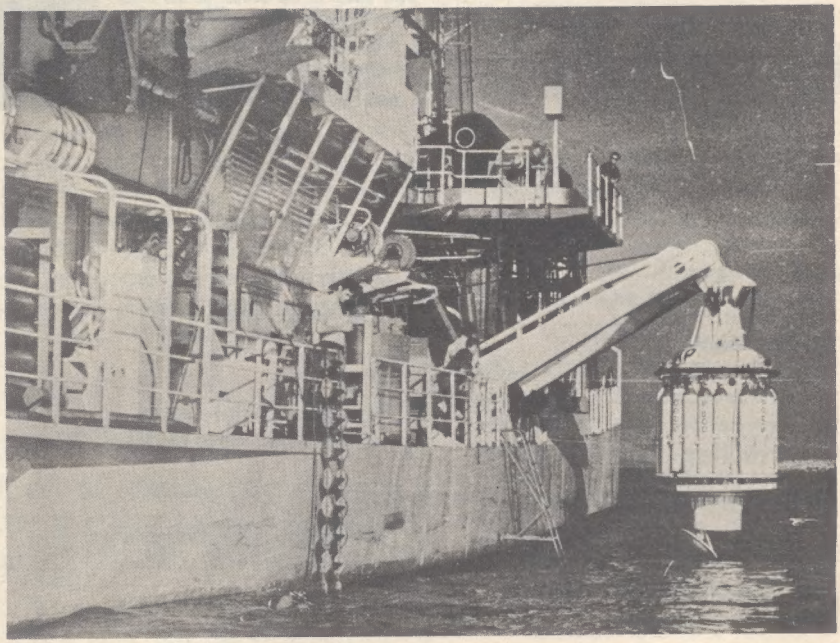

Bulletins at press time

SAFER UNDERWATER. A scientist who wants to test the narcotic potency of breathing a hydrogen atmosphere may have to go to record depths to do it. Dr. Ralph Brauer, a physiologist and director of the Wrightsville Marine Bio-Medical Laboratory, will be breathing hydrogen while seated outside a French diving sphere (above) as it is lowered "well beyond 800 feet." He is not trying to set any diving records. The experiment could be conducted on land, in a pressure chamber, but hydrogen under pressure is dangerous, and it is far safer to work underwater. The test is scheduled for the second week of June.

ASTHMA AND EMOTIONS. Nineteen out of a group of 40 asthmatics developed asthmatic reactions after being tricked into believing they had been breathing allergic agents. They had actually been breathing a nonirritating salt water mist. Some of those who suffered attacks improved after being told they were being given a remedy. It was the same water mist.

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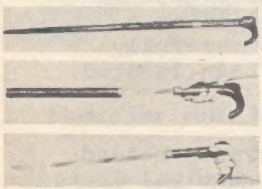

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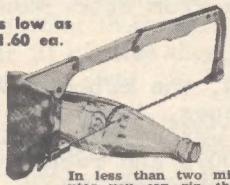

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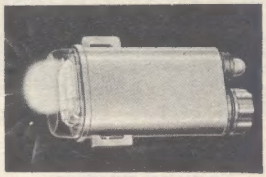

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SIGNALS OR SPINNING STARS? The pulsars, sources of rhythmic radio pulsations from space, may be coming from rapidly spinning neutron stars, small dense bodies, that result from the catastrophic collapse and explosion of a large star. The pulsations were so odd that astronomers first thought they might be signals from other worlds (see p.35).

THE BLACK DEATH AGAIN. The bubonic plague, the Black Death of the Middle Ages, is on the rise in Vietnam. Some scientists have warned of the increasing danger of plague (see page 90), and recent statistics seem to bear out the dire predictions.

SECRET PYRAMID ROOM. Scientists who have been counting cosmic rays as they pass through one of Egypt's famous pyramids, believe they have found indications that there is an undiscovered chamber in the pyramid built by the Pharaoh Chephren. If the pyramid is solid, then fewer particles should be getting through. Most pyramids have several rooms, but only one has ever been found in Chephren's pyramid, leading to the theory that the real burial chamber was carefully concealed from robbers and has not yet been located.

WHOOPERS ON THE RISE. As the whooping cranes headed north this spring, prospects for their survival looked better than ever before. Forty-eight known specimens of the majestic bird flew to their nesting grounds in Canada. Conservationists are now hatching a few whooper eggs in captivity, where the young will have a better chance of survival. The birds will then be released.

SAFER AT THE TOP. A massive study of employees of the Bell system showed that executives had a slightly lower rate of heart disease than blue collar workers.

ANOTHER ICE AGE. New observations seem to indicate that past ice ages were caused because of a lessened tilt in the earth's axis. If the theory is right, Europe and North America may face another period of glaciation in about 80,000 years. With a smaller tilt, there is less contrast between winter and summer, and ice collected during the winter does not melt fully.

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Here comes Icarus

by Bruce Frisch

On June 15 a missile with the destructive potential of 7,000 100-megaton thermonuclear bombs will streak within 4,000,000 miles of earth. It will be the asteroid Icarus making the decade's closest known approach by an astronomical body other than the moon. What will happen?

To see how destructive asteroids can be just look at the ravaged, pockmarked face of the moon. That is what earth would look like if rain and mountain-building did not give it a face lifting. Recently, Dr. Harold Masursky of the U. S. Geological Survey has been examining craters on earth in preparation for the moon landings, and concludes large impacts are more frequent today than had been thought. Perhaps, he says, we should look into having an asteroid watch and warning system.

Dr. Masursky has inspected the Barringer Meteor Crater near Winslow, Ariz. It is about 4,000 feet across and 570 feet deep. A 100-ton asteroid blasted the hole 20,000 to 50,000 years ago. The heat of the explosion probably killed everything for five miles around.

At eight miles wide, the Sierra Madera crater in west Texas is the biggest in the country. Less than 3,000,000 years ago, figures Dr. Masursky, it was excavated by a stony meteorite (an asteroid that has landed and been found) several hundred feet in diameter.

The biggest still-recognizable crater in the world is the Vredefut Ring in South Africa, 27 miles wide.

Most meteorites are a ton or less. They get slowed to a halt high in the atmosphere and simply fall to the ground, but anything over 1,000 tons is hardly slowed at all, and may slam into earth at up to 37 miles per second.

Hefty meteorites weighing a ton or more dig craters. The latest known crater-size hit was on Feb. 12, 1947, when a fireball spouting sparks and trailing thick black smoke fell in the Sikhotay-Alin

A faint line on an astronomical photograph taken in 1949 gave astronomers the first hint that Icarus was on the way. Since that time they have been able to determine that the asteroid will pass close to the earth. Perhaps too close for comfort, because these interplanetary wanderers have struck the earth in the past.

Mountains of Siberia. An expedition to the site found more than 100 craters up to 25 feet across scattered among a square mile of scorched and felled trees.

What would happen if something more massive hit? Dr. Gerald Hawkins of Harvard Observatory has run some numbers through a computer and come up with this picture: A 55,000,000-ton meteorite plowing in at the moderate speed of about nine miles per second would dig a hole 6.2 miles across. Within one minute a mushroom cloud would push up into the ionosphere and block out the sun for more than 120 miles in every direction.

These, of course, are all piddling sizes. The Barringer meteorite was probably just 110 feet in diameter; Dr. Hawkins' blockbuster, ■ mere 1,700 feet.

Eros, the biggest asteroid that dips in close to earth is 15 *miles* in diameter. It was also the first to cause a stir by coming close, in 1898.

During the 1930s, three asteroids skimmed in closer than Icarus will. Apollo came within 2,000,000 miles in 1932, Adonis within 1,000,000 in 1936. In 1937 they were topped by Hermes, which looped within 485,000 miles, the closest approach yet observed. All three are about one mile in diameter. An asteroid just that size created the crater Copernicus on the moon, says Dr. Masursky. Copernicus is 60 miles across, two miles deep. Cliffs 1,000 feet high wall it in. And where are Apollo, Adonis and Hermes today? No one knows.

Most close-approach asteroids are small, and their reflected light is faint. By the time they are close enough to be seen they are going so fast across the sky they are difficult to sight and track. "We are aware of these close-approaching asteroids only through the accident of discovery," says Dr. Robert Richardson, who helped calculate the first rough orbit of Icarus, when he was on the staff of Mount Wilson-Mount Palomar Observatory. "No one knows how many objects ranging in size from a few miles in diameter downward may pass near the earth each year without being noticed."

It might be a good idea, suggests Dr. Masursky, to include asteroids in the geologic watch that is gaining favor among scientists. "One array of instruments might

take care of it all—warnings of earthquakes, volcanic eruptions and cosmic bodies," and could be tied into the present tsunami warning net. Asteroids do not have to hit the ground to be destructive, he points out. The shock wave could flatten whole towns, and an ocean landing could produce a tsunami. Given enough warning, however, we might blow up an approaching asteroid or steer it away.

Comets quite spectacular

While the human race almost ignores the menace of the asteroids, it gets positively hysterical over comets. The reason is obvious: Comets are the most spectacular events in the heavens. The comet of 1882 could be seen in broad daylight. During its passage in 1910, Halley's comet spread its tail across more than half the sky.

The tail is a stream of gas and dustlike particles boiled off the front by the sun and pushed away by the force of sunlight. The nucleus is a "dirty iceberg" of ice holding together blocks of meteoric material. As the ice melts, blocks drop off and spread out around the comet's orbit. When the earth passes through a comet orbit, we get a meteor shower, flashy perhaps, but amounting to nothing more than a fine powder by the time the burnt-out particles settle to the ground.

On the average, a comet is 1.2 miles in diameter (twice Icarus) and weighs about as much as Icarus, but the very largest stretch up to 1,900 miles and weigh 10,000 times as much as the largest close-approach asteroid. So there is no doubt a comet can pack a punch. Witness the craters on the moon which have rays, possibly the result of a comet's frozen gases exploding.

Dr. Otto Struve, professor of astronomy at the University of California at Berkeley, estimates the likelihood of a cometary hit is once in about 200 million years. It thus seems amazing that the last hit was in 1908, when the Tunguska comet knocked down trees for 50 miles around in Siberia. If it had arrived just four hours and 47 minutes later, points out Dr. Stuart Inglis, astronomy professor at Chabat College, California, it might have landed on Leningrad.

Most of us will overlook the biggest missile around simply because it is so familiar. Yet there is not only the possibility that it will hit us, there is a certainty. I mean, of course, the moon.

Although the collision will be awesome, it is doubtful whether anyone will survive events leading up to it. A day is getting longer by about 0.0016 second per century. A clock started at noon today will read 12 o'clock 29 seconds too early a century from now.

The tides are mainly responsible for slowing us down. As the earth slows, the moon draws farther away. In about 100,000,000 years, the moon will hang over one spot on earth, because the lunar month

American Museum of Natural History

Closest approach of an asteriod within recent years was by Hermes in 1937, when it came to within 485,000 miles of the earth. Model shows comparative size of Hermes and New York City. Asteroid would make crater 60 times its own diameter if it hit.

and our day will be the same length, about 50 of our present days. Lunar tides will then cease, but the sun's tides, about half as high as the moon's, will continue to slow the earth, and then the moon will start advancing toward the earth.

As it comes closer, the earth and moon will pull on each other harder and harder. When the surface of the moon is 4,860 miles overhead, the moon will be drawing the oceans toward it 576 times more strongly than it does now. A towering permanent high tide will flood the lands under the moon, leaving shores high and dry one-quarter of the way around the globe. At this moment (geologically speaking) the moon will give way under the earth's tidal pull. Just as once happened to a moon of Saturn which ventured too near, our moon will break up and spread around the world in a ring.

The ocean will level out once more, now flooding places once hundreds of feet above sea level, and life should be uneventful for eons more. Eventually, the chunks in the ring will move in closer until they start grazing the atmosphere and plunging to earth in a rain of destruction.

But long before, our lengthening days will become unbearably hot. Storms will rage where hot air from the light side clashes with cold air from the dark side. In the end we may approach the conditions on

The sun is losing energy all the time, but don't worry about freezing. We will burn up long before the sun dies, for it will swell into a red giant, so large that its surface will approach the orbit of the earth. This will certainly boil our atmosphere away.

Venus, which has an atmosphere, and a day 250 earth-days long. There the cold side is around 400°F, the hot side, 1,100°F.

Apparently there is no way of escaping a charred ending. The sun is getting hotter and more energetic all the time. It has been doing so for most of its existence, though it has only stepped up its heat output by 20 percent so far. This slow, orderly warming up will continue for a long time into the future.

Eight billion years from now the sun will rapidly cool to a reddish glow, but swell enormously, becoming a red giant. Energy will pour out thousands or tens of thousands of times faster than now. In a few hundreds of millions of years, the red giant stage will be over. Either by flashing up as a nova or by sending its outer shell billowing more gently out into space the red giant will reveal a tiny, hot white dwarf inside. Slowly it will cool into a dead black dwarf.

"One result of the evolution of

our sun through the red giant phase will very likely be the reduction of our earth to a bleak, charred cinder," says Dr. Carl Sagan, Harvard exobiologist. "As the swollen distended red sun increases in size, the oceans of the earth will boil away. The top of the terrestrial atmosphere will become exceedingly hot, and our atmosphere will evaporate away to space. Eventually the sun will engulf the orbits of Mercury and Venus; its surface will approach the orbit of earth."

All this is likely to be a postscript to the human race on earth, however. Just 4.5 billion years from now, while still in its slow, orderly growth, the sun will shine with twice its present power, and we will be receiving as much energy as Venus does today. One billion years later, as the pace picks up, we will be sweltering under a sun three times as bright as now.

Then there is a very good chance the red giant will instantaneously transform itself into a white dwarf by exploding into a nova. In ***hours***, the giant's power would increase 500,000 times. "The earth and all the other planets as well would be instantly turned into a thin gas," says Dr. George Gamow, professor of physics at the University of Colorado.

The outer shell of the sun would be blasted off, becoming a scorching wind blowing past what is left at 600 to 1,000 miles per second.

Collision of the sun with a thin cloud of dust or gas called an interstellar nebula would have an effect similar to a nova, says Dr. Gamow. "If a star, moving through space at a very great velocity, enters such a cloud of dilute material, it will burst into high luminosity in the very same way as does a meteorite that enters our terrestrial atmosphere. And, in fact, the kinetic energy of stellar motion, when thus transformed into heat, can easily supply the tremendous radiation characteristic of novae." However, the chances of either kind of collision are extremely remote.

Let's get back to sure things, like a nearby supernova. Compared to a supernova, a nova is a midget. The supernova blows just as fast as a nova, but increases in brightness as much as billions of times.

On the fourth of July, 1054, a supernova appeared which could be seen in the daylight for 28 days.

In **1054 AD** a star exploded and its remains are still visible as the Crab Nebula. A similar end might overtake our sun.

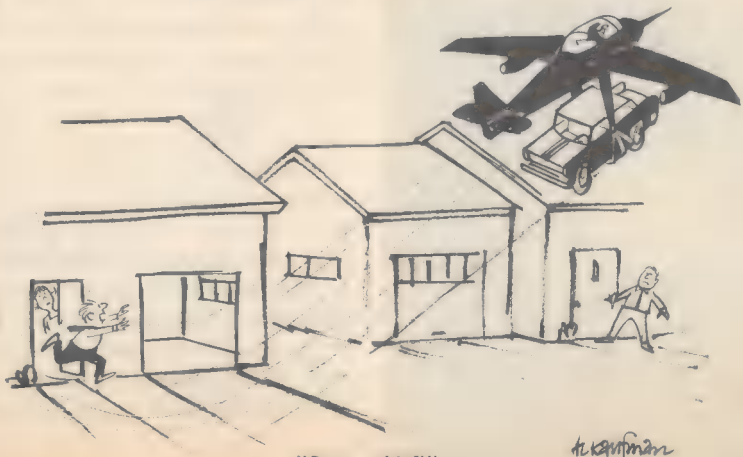
Its remnants are now the Crab Nebula. One happens nearby about once every 750 million years, say Dr. Iosif Shklovskii, Russian theoretical astronomer, and Sagan. To them, "nearby" means within 10 parsecs, or about 33 light years. The Crab Nebula is 1,300 parsecs away.

What will happen when the next one explodes? The supernova will light up the night. It will be a million times brighter than the brightest star, and 40 times brighter than the moon. After several months it will fade, but the faintly luminous gas of the supernova's ejected outer layers will spread across the sky. In about 10,000 years the gas will sweep over us, bringing with it a barrage of cosmic rays lasting for several tens of thousands of years.

The radiation dose our bodies will receive might increase by 10, doubling the mutation rate. While Dr. Shklovskii thinks this mutation rate caused by an earlier supernova may have done in the dinosaur, Dr. Sagan doubts it. At the least though, lives will be shortened, and there will be more miscarriages, stillbirths and genetically defective newborn.

Two other scientists think all the cosmic rays will arrive over a few days at most. This would mean, first, that supernovae up to a few hundred light years away would be dangerous, and second, that the danger would be not from mutations, but from immediate death from heavy radiation.

Well, that is all in the future, and we will have years of warning. Icarus is the next thing to watch for, and we have its orbit figured out perfectly, haven't we? Sure, agrees Dr. Richardson, but adds, "A change of only a few degrees in the position of the descending node of Icarus' orbit, the point at which the asteroid crosses the plane of the earth's orbit from north to south, would make it possible for Icarus and the earth to be at the same place at the same time."



"Stop—thief!"

How fragile is an egg?

For years egg dealers and poultry breeders have tried unsuccessfully to develop a device that could tell how fragile an egg is without cracking it.

A government scientist, in cooperation with the Atomic Energy Commission, has now built an instrument that gives the answer in 15 seconds, without disturbing the shell at all.

Paul E. James, an engineer with the Agricultural Research Service in Beltsville, Md., is the inventor. He believes that when his device is adapted to commercial use, it could help chicken-breeders select lines of laying hens that produce stronger and better-protected eggs.

About three percent of all eggs produced in 1965 were broken before they reached consumers, so stronger shells would benefit both consumers and businesses that handle eggs. Eggs that resist breaking also could be adopted more easily to mechanical handling.

Called a backscatter gage, the instrument "analyzes fragility by firing beta energy particles at an eggshell and counting the particles that bounce back," says the inventor. "If the shell is strong, most of the energy bounces back, resulting in a large number of counts on a counting device; but if the shell is thin, very little energy is reflected."

The machine is still in the experimental stage, but James hopes to shorten the time needed for measuring shell thickness.

This machine tests the strength of an eggshell in 15 seconds without cracking it. The shell is placed on gage at left, and the device at right determines its strength by firing beta energy particles at the egg and counting how many particles bounce back.

Lois Darling, from "Evolution of the Vertebrates"

Antarctica's most distinguished former resident

LAST DECEMBER, a team of Ohio State geologists working in Antarctica turned up a small piece of fossilized bone. Only two and one-half inches long, the fragment lay in a dried and frozen ancient stream bed among plant fossils from the early Triassic Period.

Convinced they had made an unusual find, the geologists shipped the piece of ancient bone off to the American Museum of Natural History, where it was examined by Edwin H. Colbert, a paleontologist. His identification was positive: the fragment is part of the jawbone of a *labyrinthodont*, a group of extinct amphibians that lived about 200 million years ago.

The announcement is startling. Not only is the tiny fossil fragment the first fossil of a land animal ever found in Antarctica, but its discovery adds support to the controversial "continental drift" theory. According to this theory, Africa, Australia, Antarctica, South America and India once formed a supercontinent called Gondwanaland that broke up and slowly drifted apart. (*Science Digest*, January, 1968)

If this supercontinent existed, its proponents say, life forms found in one of the present southern continents should be found in the others in circumstances indicating they lived about the same time.

Bones of other labyrinthodonts have been found in Australia and South America in rocks of about the same age as those that held the Antarctica fossil. Antarctica, isolated by hundreds of miles of stormy seas, couldn't be reached by a fresh-water animal like the labyrinthodont—unless the continents were joined.

Scientists have known for some

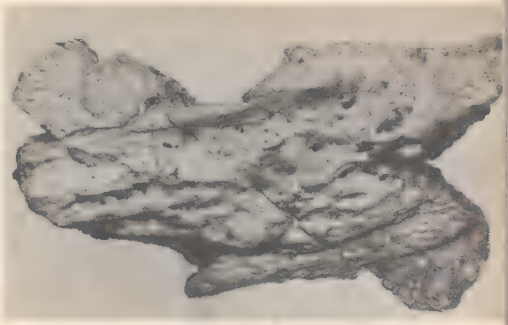
time that Antarctica once had a warm or even tropical climate that could easily have supported animals like the labyrinthodont. Large fossil trees, fossil ferns and seams of coal have been found there. Until now, however, the only vertebrate fossils that have been found are penguins.

The labyrinthodont identified by Dr. Colbert was about three or four feet long, he says, and looked something like a giant salamander. Short-legged and heavy-bodied, it probably moved quite slowly. Although it liked water, it spent much of its time roaming the dense vegetation bordering fresh water streams of the era.

"As soon as I saw the fossil, I had a good idea of what it was, but of course I checked it carefully," Dr. Colbert says. The specimen, although small, has diagnostic features that make it possible to identify, he adds.

Explorers might also expect to find fossils of other amphibians, primitive reptiles and even some mammal-like reptiles in the same area of Antarctica as that which held the bones of the labyrinthodont, he indicates. The fossil was located in the mountainous country east of upper Beardmore Glacier, about 325 miles from the South Pole.

The difficulty in finding fossils in Antarctica lies, of course, in the ice-covered terrain of the southern polar continent. The discovery of this fossil was made by a geological team investigating rock strata se-



American Museum of Natural History

Shown above is the small fragment of fossilized jawbone found in Antarctica last year. It has been identified as part of a jawbone of a labyrinthodont, a group of extinct amphibians that lived 200 million years ago. (An artist's restoration of a labyrinthodont is pictured on opposite page.) The fossil adds support to controversial continental drift theory. Below is drawing of supercontinent thought to exist before the split.

quences to learn more about the extent and flow direction of the ancient Antarctic ice sheet. Headed by New Zealander Peter J. Barret, the geological study was funded by the National Science Foundation.

Will other fossils turn up in the icy wastes of Antarctica? With more and more scientific teams working in the area, it seems likely.

MEDICINE

If it itches, what is it?

Itching is not often taken too seriously, but to those plagued by poison ivy, mosquito bites, sunburn or allergies, it's no laughing matter.

by Frank Rosen, M.D., and Ruth Winter

A YOUNG BUSINESSMAN'S hands itched only on Friday. Was it Friday's lunch, or worry about the approaching weekend?

It was neither! The cause was money. Each Friday, the businessman made up the payroll. He had an allergy to nickel which didn't bother him if he handled an occasional coin, but did cause a reaction when he counted out the wages.

Many things can cause an itch. Everyone knows when they have one. But no one really knows what it is.

Basically, an itch, a pain and a tickle are probably related. An itch is believed to be a modified pain sensation triggered by a stimulation of the nerve endings. Pain's purpose is to inform us there is something wrong somewhere in the body. An itch, however, is often accompanied by a visible rash or welt which clearly informs us there is a prob-

lem. If it is not to inform, what is the purpose of an itch?

If an itch and a pain are similar, why is it more acceptable in public to rub a pain than to scratch an itch? A person who scratches before others is considered a boor. A person who demonstrates pain is pitied.

It can strike anywhere

An itch may be perceived anywhere in the body—even on hard skin—except on a callus. Unlike pain, an itch does not radiate. At times, however, an itch is such a generalized feeling that while it is felt on a broad area of the body such as the face or back, the spot cannot easily be located.

A tickle is a withdrawal in response to a light touch or stroke, especially in sensitive areas like the bottom of the foot or the ribs. While a tickle may be relieved merely by touching the tickled site or withdrawal from the source of the tickle, the response to an itch is scratching.

Itching can be continuous, mild, severe, intolerable, throbbing or pricking, and once a person has had a condition causing an itch, he is more susceptible to itching in the future.

An allergy, the body's reaction to an antigen (foreign substance), is probably the most frequent cause of itching. Half of all the patients who visit a doctor's office because of a skin problem are suffering from eczema. Eczema is used to describe all types of itching skin rashes which are allergic.

When an antigen from outside sources causes a rash, the eczema is called contact dermatitis. This condition is usually limited to the areas of the skin actually touched by the offending material, but acute attacks may spread beyond these areas.

Many substances produce rashes and itching. Among the most frequent are dyes used to color clothing or to dye hair, chemicals in cosmetics, shampoos and creams, lacquers, plastics, mercury and nickel compounds, furniture polishes and detergents.

Housewives eczema

The term "housewives eczema" is applied to a condition of the hands so common it affects 10 to 15 percent of all patients who visit doctors' offices because of skin conditions. Although this rash is most frequent in winter among women whose hands are in and out of watery cleaning solutions, it can occur any time of the year, and in men who have little contact with water.

One of the most common allergies in early childhood is eczema. It usually begins in infancy with an itching rash on the face and progresses to other parts of the body, particularly the elbows and knees. In many of the eczematous children,

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Dr. Rosen is a Maplewood, N. J., allergist and past president of the New Jersey Allergy Foundation.

skin tests show reactions to foods and other substances, and a good many of these items can be proven to cause the eczema. Food is the most common. Even breast milk may contain traces of foods eaten by the mother to which the baby is allergic.

If you are superstitious, an itching palm means money. On the other hand, if the itching persists, reddens, rings and worsens, the root of the evil may not be money, but the onset of a ringworm fungus infection. This type of itching infection is on the increase and has become the sixth leading cause of skin disorders among Americans, according to Dr. Gerald N. Wachs, dermatologist and assistant medical director of Schering Laboratories, Bloomfield, N. J.

Ringworm quite common

It has been estimated that more than 90 million persons in this country have suffered from one or more ringworm attacks. Visible warning signs include a ring or circle which expands, blisters, scales, fissures and macerations. Itching is, of course, bothersome. Ringworm fungus attacks not only the hands, but also the scalp, beard, body, groin and feet, and the infection tends to spread readily from one person to another. Another classic example of this is athlete's foot.

No one knows why some persons are immune to the infection and why others are susceptible to frequent attacks and why still others can apparently transmit the infection without having any visible signs of the disease.

Like ringworm, scabies, an ailment often referred to merely as "The Itch," can affect places on the body most embarrassing to scratch in public. The mite, which causes mange in dogs, causes scabies in people. Because of the difficulty in finding the mites on humans, it is often misdiagnosed. The diagnosis in man is usually made from a diagnosis in his pet dog. The mite does not reproduce in man's skin and, if exposure is not continued, an infestation may last no more than five weeks. For those who have had "The Itch," this is too long.

Hives may be called "allergic mosquito bites" because that is just what they look and feel like. Formally known as urticaria, they are temporary swellings which start below the skin surface and may be caused by a variety of allergy producing substances although often no cause can be found. The allergens frequently pinpointed are food and drugs—particularly penicillin. Anyone who has once had hives following a dose of penicillin should inform his doctor of this fact. The next reaction may not be hives but anaphylaxis, a severe allergic reaction which can result in death.

One of the worst itches known to man is caused by certain sumac plants such as poison ivy and poison oak. Poison ivy is a dark, green, shiny, three-leafed plant which usually doesn't grow over a foot high. You don't have to touch

Poison ivy is one of the most maddening itches, and its victims sometimes suffer for weeks.

the plant itself to fall victim to its poison. A dog or cat may run through the woods and carry the oily toxin back to the family. Many people have been poisoned from very fine droplets of the plant oil carried aloft in smoke and deposited upon the clothes or skin.

Poison ivy puts hundreds of people into the hospital every year and thousands more go at least once to a physician's office because of it. Unfortunately, there is no cure for the maddening itch of poison ivy, although antihistamines and steroids may help. It is best to seek medical advice, particularly when the face or large areas of the body are affected. A doctor should always be consulted when the poison affects the victim internally.

Advertising has kept us acutely aware of dandruff by showing us men and women either scratching their scalps or brushing white flakes from their shoulders. Despite our familiarity with the condition, the cause of dandruff is really unknown. It is believed to have some relationship to disfunction of the oil glands in the scalp since it occurs in persons with oily skin. Such people are more prone to develop acne and other chronic skin conditions.

However, oiliness and flakiness of the scalp are entirely normal phenomena and even the healthiest of human scalps shows some degree of scaling since all the skin on the body sheds a bit of its outer layer every day. On the head, extra oil glands add their secretion to the dead scale. This combined with dust and germs from the air form the scale that is known as dandruff.

There have been cases reported of babies being allergic to their mothers' dandruff. When the mothers were instructed to wear caps when holding the infants, the children's rashes cleared up.

Itching may be warning

Itching can sometimes be a sign of serious illness. It may be the only warning of a systemic disease such as diabetes mellitus, nephritis, diseases of the liver, cancer, leukemia, Hodgkin's disease, gout and thyroid disfunction. Natural conditions as pregnancy and menopause may be accompanied by itching.

Did you scratch yourself while reading this article? Talking about itching can create the sensation of an itch which people attempt to scratch without being aware of it.

Itching does seem to be more frequent in nervous people. In fact, many chronic skin conditions such as neurodermatitis—chronic itching with superficial inflammation of the skin—are believed to have a substantial psychological cause. However, it has been found that taking an itch to a psychiatrist may sometimes make it worse. Even

patients who have had no itch when they began psychoanalysis developed one while ventilating deep-seated emotional problems.

Some people are accused of being slightly daffy because they feel insects crawling on their skin. Victims of alcoholism and schizophrenia often try to brush off imaginary bugs. However, some tiny mites do attack people. They cause an intense crawling sensation on the skin and a momentary but intense itching. Because they are smaller than the point of a pin, they usually cannot be seen with the naked eye.

Mites are just one of the almost endless list of things that can cause itching. Heat rash or prickly heat is an acute inflammatory condition due to the obstruction of the sweat ducts. The prickling itch is maddening and so is the intense itching of chicken pox. The itching is so bad in chicken pox that even though they are warned that permanent scarring of the skin may result, victims cannot restrain themselves from scratching.

Heat, pressure and accessibility all influence the severity of itching. Accessibility is being able to scratch the place that itches. Itching is worse at night. Perhaps it is because we are too busy during the day to concentrate on the itching.

Even though the sensation we call "itching" is not fully understood, there are some techniques for relieving it. Ice, for example, will make itching disappear temporarily. But it may make the itch worse later.

Antibacterials and antifungicides will cure an itch by inhibiting the growth of the organisms. Steroids may help the inflammation, but not necessarily the itch. Antihistamines are more effective as preventatives than cures. Electron beams and X-rays are used occasionally. When nothing else works, tranquilizers and sedatives are valuable in allowing the tormented to relax and get some rest.

Unfortunately, itching tends to perpetuate itself. The more you itch, the more you scratch, the more the scratch itches.

This multiple exposure photograph approximates what a viewer sees as he moves his head from left to right in front of a new kind of hologram (a photographic record that reproduces a 3-D image) made at Bell Telephone. Image rotates 360 degrees.

Science Month

The real green cheese

SCIENCE has come to the rescue of young lovers, songwriters and poets. The moon is not a mere dead rock, nor is it a cold glob of congealed gas or dust. It is a warm-hearted chip from the old block, earth. For future moon colonists, a large store of oxygen is locked chemically into its basalt rock. There is silicon too, for glass, iron and aluminum, and other metals.

Such is the opinion of many scientists as they study the recent Surveyor 5 moon-soil analyses. The landing was in the Sea of Tranquility, one of the many waterless *seas* that cover a fifth of the moon's visible surface. The atomic soil analyzer found that the moon rock contained 53 to 63 percent oxygen, 15.5 to 21.5 percent silicon, 10 to 16 percent sulfur, iron, cobalt and

nickel, 4.5 to 8.5 percent aluminum and lesser amounts of magnesium, carbon, sodium and elements heavier than nickel.

If you wanted to whip up a batch of basalt, this would be a perfect recipe. The analysis also strengthens the theory that the moon's *seas* were formed when meteor collisions cracked the moon's surface. Basaltic lava flowed up through the cracks, then cooled to form large dark-appearing sheets over depressed areas.

Basalt is widespread on the earth. It came as red hot, liquid lava from volcano chimneys, or was squeezed up through deep earth cracks. Basalt is also the three-mile-thick skin of hard rock that entraps the earth's fluid interior. This basaltic crust is the base for the oceans and is the platform on which perch our great continents, towering piles of granite up to 40 miles thick.

Basalt is seen in areas of geologically recent volcanic activity. Most Atlantic and Pacific volcanic islands are basaltic. Layers of crystallized basalt lava form the 100,000-square-mile plateaus of the Snake and Columbia Rivers in Washington. The 200,000-square mile Deccan Plateau in India is underlaid by basalt.

Most spectacular are the four-, five- and six-sided basalt columns. They formed when the molten rock split vertically as it cooled and shrank. Basalt columns are in the Hudson River Palisades in New Jersey, opposite New York City. Other columns are in the cliffs along the Columbia River in Washington, at Devil's Tower in Wyoming, at the Devil's Postpile south of Yosemite National Park in California, at Fingal's Cave on the island of Staffa off Scotland, and at the Giant's Causeway in Ireland.

Along the Rhine River, slender columns of basalt are pried loose to be used as fence posts. In the U.S., there are many basalt quarries. Crushed basalt is trap rock, used for road-building. In days past, trimmed basalt was used as cobblestones. *—Robert Davidson*

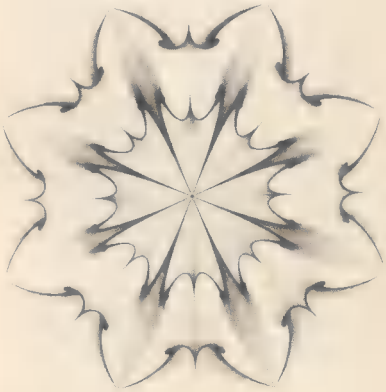
The criminal chromosome

A small but significant number of the inmates in prisons or mental institutions have gross chromosomal errors which have never been identified, a team of researchers from Elwyn Institute in Pennsylvania reports.

Since chromosomal errors often result in extreme body height, the team studied only tall men (71 inches or over) in four institutions in Pennsylvania. One in 11 proved to have such an error. The imbalance was most prevalent in a hospital for the criminally insane, where one out of eight patients showed a chromosomal error.

In the population of tall men at large, the comparable incidence of sex chromosome errors is estimated to be about one in 80.

Chromosomal errors contribute,



These four pictures are products of a little known but interesting art form, computer/plotter art, which uses the combined talents of man and machine. Computers, made by California Computer Products, Inc., Anaheim, Calif., were fed countless mathematical computations, which were then placed on tape. The tapes were run through CalComp Plotters to create the pieces of artwork. Even though angles and curves are shown in the drawings, they are actually straight lines. While venturing into the art world, even so far as sponsoring art contests, CalComp Plotters are being used mainly for such pursuits as generating garment patterns from designer's original patterns quickly, producing contour maps for oil exploration and other industrial uses. Titles are, from top left, clockwise: "The Fisherman," "The Snail," "Krystollos," and the last is drawn from Japanese woodcut.

Multi-purpose space arm developed by Martin Marietta's Denver division, is shown in compact and extended positions. It was developed initially for deploying scientific experiments and radar from manned and unmanned planetary vehicles.

in small but consistent numbers, to the pool of antisocial, aggressive males who are mentally ill and who are incarcerated for criminal behavior, the Elwyn group concludes. The same phenomenon was noted in England (*Science Digest*, Dec. '67.)

Earth colder, dustier

If you think it's been getting dustier and colder, you're right on both counts. The two conditions, in fact, may interact. Industrialization and the population boom are responsible for the increase in dust, which comes not only from industry but also from the primitive slash and burn agriculture of Africa and Asia. A dustier earth absorbs less heat from the sun, which may result in a temperature drop. Since 1950, studies show, the earth has been cooler.

Pollution even in Siberia

The Soviets have their pollution problems too. Despite the outcries of conservationists, pulp and paper-making plants are being built on or near Lake Baikal in Siberia, the largest fresh-water lake in the world. Already, yellow, smelly waste water is flowing into the lake from a huge wood-pulp plant with a defective purification system. Lake Baikal has—or had—a unique plant and animal life adapted to its peculiarly cold and mineral-free environment.

Chemical saves birds

More than 50 percent of the oil-soaked ducks and sea birds that were treated at a Boston animal hospital survived, the Massachusetts Society for the Prevention of Cruelty to Animals reports. The birds were rescued after a tanker dumped oil into Massachusetts waters.

The high rate of survival con-

trasts sharply to the six percent recovery rate for oil-soaked birds following the breakup of the oil tanker Torrey Canyon off England more than a year ago.

Many of the Massachusetts birds were cleaned with a liquid chemical called Polycomplex A-11 which hadn't been used before to treat wildlife. It is actually an oil dispersant developed primarily to break up spills of oil on water and beaches.

The oil had immobilized the birds and prevented them from diving for food or maintaining their body temperatures in the winter weather. When they tried to clean their feathers, they swallowed oil and poisoned themselves.

Food that's never eaten

One fifth of all food crops planted by man never reach a dinner table, according to a study by the Department of the Interior. In less developed nations, between 20 and 30 percent of grain is lost in storage and in the field. The culprits are rodents, insects and fungi. Vampire bat forays also kill at least one million head of cattle each year, particularly in South America.

Back to Bikini

Bikini atoll, site of atom bomb tests from 1946 through 1958, may soon be inhabited again. The 300 ex-Bikinians await a decision from a panel of specialists as to whether levels of radiation on the atoll are low enough for human habitation.

One island, Namu, all but sank under the many atom blasts, but the other 20 islets of the atoll still exist. Coconut palms and breadfruit trees again wave in the breeze and animal life flourishes as it did in the days before the tests. Radiation levels in the flora and fauna have dropped to the level of the slight natural radioactivity given off by the normal environment, according to University of Washington researchers.

The former inhabitants of the atoll are living on Kili, a 120-acre island about 500 miles to the south. Although the Bikinians chose Kili, they now regret the decision. Kili has no lagoon to provide a rich variety of ocean life, it has too much rain and there are no islets to use as plant nurseries, livestock pens or animal sanctuaries.

A look at legs

Dr. Martin Cole, a geneticist at Aston University, Birmingham, England, will study photographs of a thousand pair of women's legs to find out more about their shape. He hopes to discover whether social class has anything to do with the shape of the leg. The photographs of the legs will be taken by Dr. Cole's female colleague.

NEW FOR PEOPLE

With mere flick of switch, you get an electric pointer, slide previewer simultaneously in this Cordless Pointer-Previewer. Sharp light points; translucent wand with diffused light is for viewing slides in dark. Ednalite Corp., 202 N. Water, Peekskill, New York.

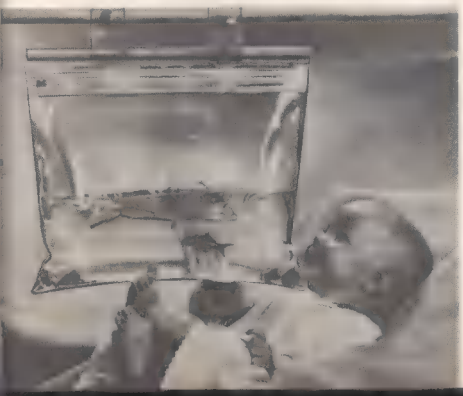
Left: Thousands of fragrances are available for the home, car or office. They come in small appliance-like devices. Conair, 20 Harold Ave., Santa Clara, Calif.

Pocket-sized movie viewer accepts any standard three-inch Super 8 film reel. Hudson Photographic Industries, South Buckhout St., Irvington-on-Hudson, N. Y.

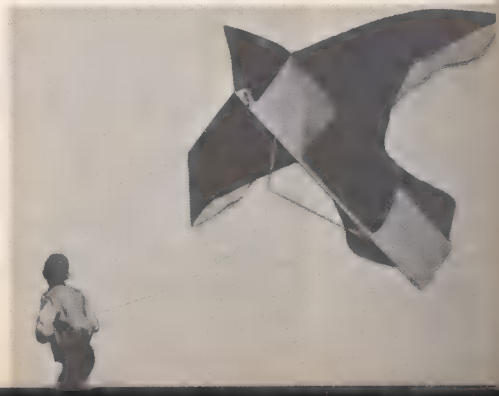
It will break if you try hard enough, but this Tuff-Skin incandescent light bulb with silicone-rubber coating is 70 percent more resistant to physical impact than normal household light bulb. Made by General Electric, Nela Park, Cleveland, Ohio.

New to the microwave "cooking in just seconds" field is RCA. This electron tube is used at lower frequency than previous ones and permits uniform cooking of thin foods like bacon. RCA's Electronic Components Plant, Lancaster, Pennsylvania.

Cradle learning in the 21st century may include innovations such as this baby getting a lesson in water animals right in his own crib. New theories of play and toys are undergoing tests at Creative Playthings Laboratory, Princeton, New Jersey.



Here's a kite to tickle anyone's fancy—child or adult. Called SPACE-BIRD, this multi-colored (red, pink, blue, green, orange and black) cloth kite comes from Alan-Whitney Co., P.O. Box 447, 165 Dwight Street, New Haven, Connecticut.



The multiple sounds of youth

Current musical devices can make one musician sound like a quartet, a sax like a clarinet and a guitar like nothing you've heard before.

by Robert A. Kelly

THE trombone sounds like eight other instruments — the saxophone has six eerie, bouncy echoes — the guitar comes complete with the "wah-wah" wail of a trumpet.

It's the newest thing in recreational acoustics — "Psychedelic

sound is the big thing in music today," says a musical trade magazine publisher. "Horns that go 'toot' and strings that sing are taking a back seat to instruments that make noises like 'wah-wah,' 'fuzz,' and 'buzz.' They're all noises likely to make an older generation go, 'Grrr!', but they're part of the rock 'n' roll revolution in music."

Let's look at some of these remarkable new electronic sound devices. Typical, perhaps, is the Vox Stereo Multi-Voice. Based on the company's Ampliphonic Pickup — an electro-acoustic pickup device installed in each instrument — the Multi-Voice lets a single musician sound like a whole section. The player resets tabs for any octaves or voices he wishes. Then, with a tap of the foot, he can change or mix octaves; swing back and forth between different voices; make a sax sound like a clarinet, or sound like several instruments playing all at once.

The company also produces another special effect device known as the "Wah-Wah" pedal. Designed to be used with a guitar, or with any electronically amplified instrument, the pedal moves the sharp sound peak back and forth through the audio range from low-to-high and high-to-low — the result is the wah-wah effect: It makes a guitar growl and imitates the sound of an on-and-off muted trumpet. In slightly more technical terms, the wah-wah is a device in which the frequency response is very sharp and peaked in one narrow range of the audio spectrum. Actually, set up as a unit which goes in series between the instrument and the amplifier, it operates on, and modifies the actual signal reaching the amplifier.

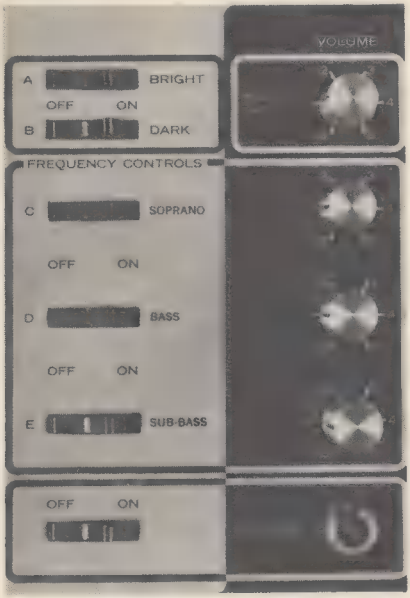
There are even available today amplified music benches complete with quality amplifiers, speakers and cushions — operating, one might say, at the seat of our musical culture.

Where does it come from?

As technology advances and amplification improves, it becomes more difficult to tell from which direction a given musical signal is coming. With the new devices, sound fills the listening area so that it seems to be coming from everywhere.

Responsible in no small part for surrounding young America with the new sound is the world's first "Ampliphonic Bank" — a musical group in which *all* instruments are amplified. The first of its kind, the new band came into being because Bill Page (over the years a regular Lawrence Welk, Ted Mack and C.B.S. musician) became aware of the fantastic possibilities of proper amplification of every instrument in his orchestra.

At the outset, it was determined at which point in each instrument the sound is most fully-developed and purest. Then the task was to develop a "pickup," to carry that sound into the amplifiers. Next, the amplifier itself, and complete speaker system, was designed to follow



LEFT: A musician wears this Conn Multi-Vider on his belt, and he can add one, two or three octaves to the instrument's normal range, each the degree of volume he chooses. **ABOVE:** This master control box mounted on saxophone lets player use seven controls to produce 60 tonal effects.

through by amplifying the pure sound picked up from the instrument. Finally, capabilities such as the Stereo Multi-Voice, Wah-Wah pedal, and many others were designed into each amplifier. The result is thousands and thousands of sound effect combinations — and the first all-ampliphonic orchestra.

You want a brass horn on a guitar? You can get it. Not surprisingly, it's called the Wurlitzer Brasshorn, and it drives guitar sound through a horn-shaped bell to produce five times the mid and trebel highs possible in standard electric guitar amplification. As a matter of fact, it creates clear brass overtones in a penetrating sound wave ranging from 250 to 12,000 cycles.

Two horn bells come with each unit with the longer bell funneling a narrow concentration of sound in a pointed direction. The short bell saturates a larger area with a broader, but no less ringing sound column.

Reaching into history, Baldwin Piano and Organ Company has "youthified" the traditional harpsichord and created a twangy, driving rock sound. Looking much like an antique instrument, the new unit is supposed to support the other instruments in a rock group — it's called "the combo harpsichord," and it's complete with electronics whereby strings are actually plucked with the sound picked up at both the bridge and at the end of the strings — hence the endless sound combinations.

There seems to be no limit to the revolution. Even the one-man-band is on its way back in a big, loud way. The Conn Multi-Vider (a musician wears the unit on his belt) adds one, two or three octaves to the instrument's normal range, each in the degree of volume he chooses.

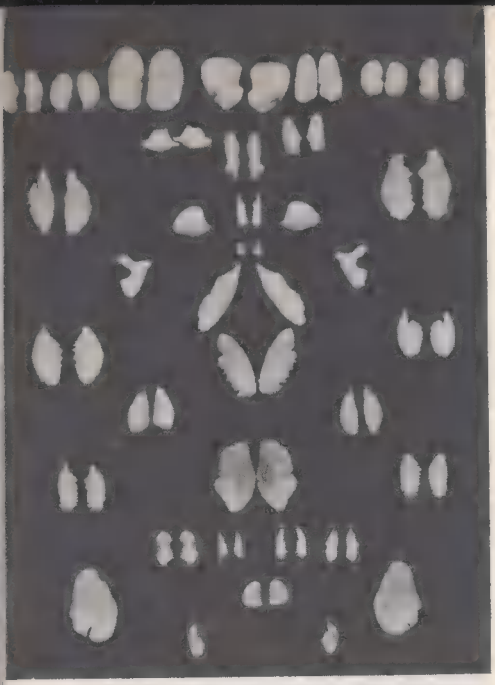
This kind of four-part unison is achieved with a tiny microphone installed in his instrument which picks up sound waves as he blows. These are multiplied or divided by a miniature digital computer in the Multi-Vider. The sound is then fed to an amplifier which can add still more special effects such as the clarinetist who plays in his own register, adds a tenor line, contributes some alto where he wishes, then blasts in with a contra-bassoon sound . . . and all done with a touch of a control panel. Or, you might hear a flute become "meaty" when the sub-bass voice is flicked on, especially in a solo.

It's not enough that guitars can now have horns like a trumpet. Here comes a guitar-organ! Actually, Murrell Electronics calls it the GuitOrgan. And it allows you to play your guitar in the conventional manner, or to produce the sounds of an organ or an organ and guitar combined. Again, portability is the theme. The unit weighs about 12 pounds and is slightly larger than a typewriter. All the frustrated organ player has to do is plug in the foot-expression-pedal and the lead from his guitar, connect the GuitOrgan to an amplifier and the world-of-organ-sounds is his, direct from the strings of his guitar.

The multiple sounds of youth are here to stay—in fact, there's lots more to come . . . and most of it seems to be for the good, even beyond rock and roll applications. For example, an amplified sax can provide better dynamic balance against the brass section; the need to double reed section parts will be eliminated; add to this the ability of almost any kind of musical group to duplicate recording studio fidelity even outdoors.

Next? All sorts of electronic marvels, without doubt. Among items already on the drawing boards: a marching band featuring speakers in each musician's hat, and multiple electronic sounds with *no cords* between instrument and speaker.

Felix of the Young Rascals plays the combo harpsichord, a "youthified" version of the traditional instrument complete with electronics to allow a twangy rock sound.



ABOVE: This collection of fish otoliths—ear bones—was assembled by marine biologists at the California State Fisheries Laboratory on Terminal Island. Ear bones at top left were taken from a kingfish; large specimens at bottom left and right, from dog snappers. **BELOW:** Minute otoliths are studied under microscope for rings and scales that reveal age of the fish.

TECHNOLOGY

Slice it thin

One doesn't usually lump diamonds and fish together in the same conversation, but scientists at the California State Fisheries Laboratory are different. To marine biologists there, diamonds are used for saw blades in research projects dealing with fish. The blades slice thin sections of fish otoliths—ear bones—which in turn reveal the age of a fish.

Because fish cannot be counted like cattle or poultry, determining ages of fish populations helps in figuring growth rate, mortality rate, age of sexual maturity. This information then guides authorities in conserving and regulating the catch of marine fish.

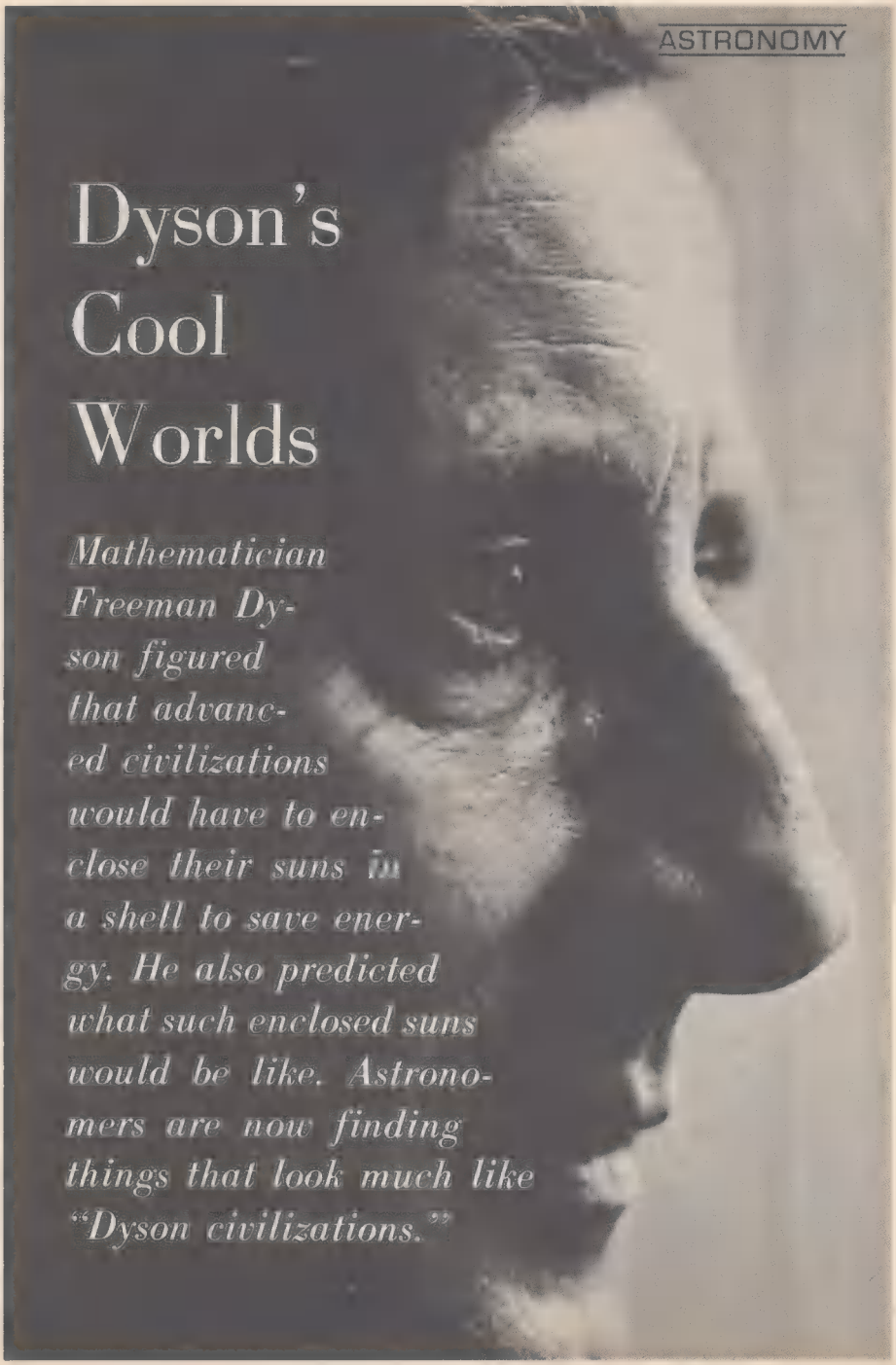
How does the operation work? A single otolith is secured in dental impression wax. The ear bone is then mounted on a precision machine equipped with an orientation head that allows 360 degree rotation with a table tilt in any direction from horizontal. Table versatility is essential.

A four-inch diameter diamond blade with .010-inch cutting width rotates at 3,450 surface feet per minute and slices sections from the ear bone as thin as .007 inch.

The cleanly sliced section can be studied under a microscope to reveal the exact age of most fish because the ear bone has clearly defined growth rings, much like the rings in a tree trunk.

Dyson's Cool Worlds

Mathematician Freeman Dyson figured that advanced civilizations would have to enclose their suns in a shell to save energy. He also predicted what such enclosed suns would be like. Astronomers are now finding things that look much like "Dyson civilizations."



By Bruce Frisch

EIGHT YEARS AGO, Freeman Dyson, a British-born mathematician-physicist at the Institute for Advanced Studies in Princeton, N. J., forecast the course of civilization 3,000 years into the future. By that time, he said, we may have completely enclosed the sun in a shell to catch every bit of its energy. To distant observers the sun would appear to be replaced by a new star shining at roughly room temperature. Thus, if we want to sight advanced civilizations elsewhere in our galaxy, he suggested, we should look for such cool stars.

Cool stars like these were unknown at the time, but over 1,000 have been discovered since. Some have recently been found to be sending out powerful radio signals. Although the phenomenon can possibly be explained naturally, some scientists are beginning to ask half jokingly, half seriously, "Are these Dyson civilizations?"

When Dyson made his proposal, the whole subject of extraterrestrial civilizations was just coming out into the open. Scientists had been quietly talking over the possibility among themselves but it was not until 1959 that two Cornell University physics professors, Drs. Philip Morrison and Giuseppe Cocconi, dared publish a serious discussion of the subject in the British journal, *Nature*. They talked mostly about how we might communicate with a distant civilization.

Radio astronomy was just getting rolling then, and large, dish-shaped antennas were being built. Almost all radio sources then known among the stars and galaxies put out static over a wide region of the radio dial. So the astronomical world was still excited over the discovery a few years before of clouds of hydrogen between the stars that broadcast on a single frequency just as a radio station does. By tuning in on station HYDROGEN, radio astronomers had been able to map parts of the galaxy hidden from optical telescopes by clouds of dust.

'Rational frequency'

To Drs. Morrison and Cocconi, hydrogen possessed the "uniquely rational" frequency for one civilization to use in attempting to communicate with others. They proposed that radio astronomers listen for such signals from nearby stars.

Unknown to them, Dr. Frank Drake at the newly completed National Radio Astronomy Observatory (NRAO) in Green Bank, W. Va., was preparing very quietly to do just that. He labelled his attempt Project Ozma, "for the princess of the imaginary land of Oz—a place very far away, difficult to reach and populated by exotic beings."

In April 1960, he aimed his 85-foot-diameter antenna toward the star Tau Ceti, 11 light years away. Silence. Later in the day, he trained toward the star Epsilon Eridani. The recording pen went right off the paper, and pandemonium broke

Have we made contact already?

In March word began to circulate that scientists had picked up signals from space which seemed astoundingly like those that might be sent out by a highly advanced civilization.

On March 28, the *New York Times* asked editorially: "Has mankind finally made contact with the space communications network of the advanced galactic civilizations whose existence has long been suspected though never demonstrated? Until a few weeks ago astronomers would have dismissed even asking of this question as fantastic nonsense. Today these same astronomers not only are themselves asking this question but some, at least, suspect the answer will be yes. Certainly no astronomical development in decades has produced such astonishment as the evidence of a new category of celestial objects, the amazing pulsars which some astronomers call LGM's, for Little Green Men."

What is astonishing about these pulsars (Pulsating Radio Sources) is their power and the regularity of their signals, once every 1.3372795 seconds. Despite this, and despite the fact that no really convincing natural explanation has yet been offered, scientists are less enthusiastic about the space civilization idea than they were a few months ago. The signals are being radiated in all directions. This would be unnecessary and a terrible waste of energy in communication. They are spread over a broad range of frequencies, also a waste, and there are probably hundreds of them. The feeling is that the pulsars are some sort of natural phenomena. But still the attractive idea of super civilizations cannot be laughed off.

loose in the control room. As it turned out, Ozma had apparently stumbled on a secret U.S. airborne military experiment. Through 150 more hours of listening over the following three months nothing else of interest happened.

Some scientists claimed interstellar communications are hopeless. A message can travel no faster than the speed of light. If another civilization were 100 light years away, it would take 200 years to send a message and get a reply. Recently, Dr. Gerald Feinberg, professor of physics at Columbia University, theorized that there are elementary particles he names tachyons that can go infinitely fast. The speed of light would be the slowest a tachyon can go. Thus communication between here and anywhere else by tachyon would be instantaneous. Only the primitive peoples of the

universe may use radio.

Dyson had a different objection. He had been thinking, "There will be radio signals only if people at the other end are interested in communicating. It occurred to me there might be other things less hypothetical" we could spot, like infrared (heat waves). "All industrial operations produce infrared," because all the energy they use eventually winds up as waste heat. As our energy-consumption increases, so does our infrared.

In our search for more energy we may find a way to catch all the sunlight that falls on earth, say Dr. Iosif Shklovskii, Russian theoretical physicist, and Dr. Carl Sagan, Harvard exobiologist. But in a mere 1,200 years that will fall short of our needs.

Solar shell next?

Next we may turn to controlled H-bomb reactions. For fuel we will use deuterium, or heavy hydrogen, which has two protons in its nucleus rather than one, like ordinary hydrogen. Only a single hydrogen atom in about 10,000 is a heavy one. Twenty-five hundred years from now, they calculate, we will consume energy at such a prodigious rate that we will use up all the deuterium in the oceans in 50 years.

The next step for an energy-hungry civilization may be a solar shell. "The earth is getting messed up very fast," observes Dyson. "We will soon come to the point where industrial operations will have to be carried out somewhere else. If you imagine industry 100 times its present scale, it will make earth an unpleasant place to live. Perhaps in 100 years or less people will find some kinds of industry will have to be moved out to space."

By that time, he figures, air-breathing boosters, regular use of expensive ground facilities and other economies will have cut space transportation costs. At first, factories will be put into orbit to reduce pollution. "The solar wind is very convenient this way." It will sweep away the dirt.

World population will grow right along with industry. "Population control will never work unless there is one very strong government. There will always be people who don't want to practice birth control. They will go off by themselves, and eventually outnumber everyone else." They and other groups will build independent city-states in space.

The factories and city-states will grow into a shell. "You can build structures that are very large. They could be as large as a million miles in diameter. Tidal forces would destroy larger ones. But they would be spidery things, not solid bodies. Flimsy, essentially balloons. It would take 100,000 of these objects to make a shell."

Jupiter could be completely disassembled to provide construction materials for a shell with a radius twice that of the earth's orbit. It would trap all the sun's radiant energy, providing about 130 trillion

Dyson advised astronomers to look for cool stars if they wanted to find evidence of super civilizations.

times the energy we now consume. The sun's energy will either heat the shell directly or be captured, used and disposed of as waste heat. Either way the shell will be warmed to a temperature between 98°F below zero and 81°F above.

Look for a star in that temperature range, suggested Dyson, and we may find the home of an advanced civilization.

Unfortunately, back in 1960 no one knew how to look for such stars. Attempts had been made as far back as 1937, using infrared-sensitive film, but the difficulties were overwhelming. At the wavelengths corresponding to these temperatures, the sky itself glows brightly, and the telescope even more intensely. In terms of visible light, it is like trying to photograph a star in daylight with a luminescent telescope.

By 1965 these problems had been overcome, and Drs. G. Neugebauer and Eric Becklin at the Mount Wilson Observatory of CalTech began taking a sky survey. At the focus of an ordinary reflecting telescope, they placed an infrared detector very much like one of the new, sensitive photo light meters. To shade the detector from heat waves, it was almost completely enclosed by shielding cooled liquid nitrogen.

Results started coming out in 1967, and by the fall 400 to 1,000 stars cooler than 1,500°F had been counted. Most of these are pulsating stars called Mira-variables, believes Dr. Robert F. Wing, an astronomer at the University of California in Berkeley. Other infrared stars have been identified as different natural objects, but some remain unexplained.

Meanwhile, a new, seemingly unconnected astronomical mystery was attracting much more attention. Shortly after the discovery of hydrogen radio emissions, Dr. Shklovskii suggested hydroxyl (OH), a combination of one atom of oxygen with one atom of hydrogen, might behave similarly. He calculated the four frequencies on which hydroxyl should broadcast, but they were not accurate enough for radio astronomers to zero in. Soon after, however, precise measurements were made in the lab at MIT. Guided by them, Dr. Allen Barrett, professor of physics at MIT, and his crew prepared to look for hydroxyl clouds with the radio telescope at the Millstone Hill Observatory.

He knew OH would not often send out radio signals, but would more likely be detected a different way. If a radio star or galaxy were behind it, a cloud would absorb energy at the same frequency it would otherwise broadcast.

In October 1963, Dr. Barrett aimed his telescope at the constellation Cassiopeia, where the remnants of a supernova explosion was a strong radio source. As he ran the

radio tuner across the dial, the speaker sounded a steady hiss until the hydroxyl frequency was reached, then it went silent. Dr. Barrett had found a hydroxyl cloud.

At first, the search for the rarer emissions failed. Finally, scientists realized they had found them, but had not believed them, because they were so strange. Australians ran across them first by accident in 1964, but thought their equipment was out of order. A half year later teams at Harvard and Berkeley discovered them, recognized them as emissions from something, but could not tell what. The Berkeley group named the unknown emitting gas "mysterium." "Although mysterium has now been identified as OH, the name can hardly be called a misnomer in view of the strange properties exhibited," said Dr. Barrett last summer.

Most puzzling was the immense power of the OH clouds. But many of the mysteries about mysterium melt away if the OH clouds are acting like masers, pointed out Dr. Barrett. The only masers we have known about are man-made. They are extremely powerful radio amplifiers, which are, in fact, used in radio telescopes.

To solve the puzzle, astronomers determined to get a sharper picture of one particularly strong source in a region of space they had labelled W3. The picture they had from their radio telescopes was very fuzzy. It was like looking at a nighttime photo that was one smear of

A man of imagination

Freeman Dyson is practically the only Mr. in this story. He never bothered to get more than a bachelor's degree in mathematics. Today he is at the Institute for Advanced Studies, where Einstein worked, as a problem-solver on the frontiers of physics.

He got his degree from Cambridge (England) University, and came to Cornell University in 1951, where he "sat at the feet of Bethe," Dr. Hans Bethe, last year's Nobel prize winner.

Besides his Dyson civilizations, he has also proposed long space voyages in which the passengers would live on the ship through several generations, or would be frozen. On such voyages, advanced civilizations may use dense, dark stars as relay stations. The ship would graze the star, being caught in the power gravitational field and flung out in a new direction. Although everyone would undergo thousands of g's acceleration, they would feel nothing, because the acceleration would be equal on every particle of their bodies.

light. If they had a sharper picture, the smear might turn out to be one searchlight or 10 flashlights. To get a better radio picture, they had to make simultaneous sightings with two widely separated telescopes.

As readings were taken with telescopes farther and farther apart, the smear in W3 got smaller and smaller, but no sharp outlines appeared. Eventually, observations by NRAO in West Virginia and the Hat Creek, Calif., observatory broke up the smear into seven different sources. One is still a blur.

The sources now looked less like clouds than, well, let's say it, other worlds. Could the OH broadcasts be interstellar communications? "It is a fascinating thought," said Dr. Barrett, "and one that has not escaped the scientists involved in OH research, although few would care to admit this publicly, perhaps.

"OH emissions have many of the properties originally suggested for interstellar signals, and sought in the search for such signals," including variations over time that could be a sort of Morse code.

"What better way would there be to attract attention than to violently upset" our calculations of what the characteristics of OH emissions should be? asked Dr. Barrett. "One *cannot* envision the receiving civilization simply *ignoring* the observations.

"There is no evidence that the OH radiation is really interstellar signalling, and I am making no such proposal," he continued, but it is "suggestive."

He would still call it no more than suggestive after the bomb dropped at an astronomy conference in Charlottesville, Va., late in 1967. Dr. Ernst Raimon, a Dutch astronomer on the way home from CalTech, told the assembly that an infrared star in the constellation Orion is in practically the same spot as an OH source. There could be two more pairings, he went on, in the W75 region and W3.

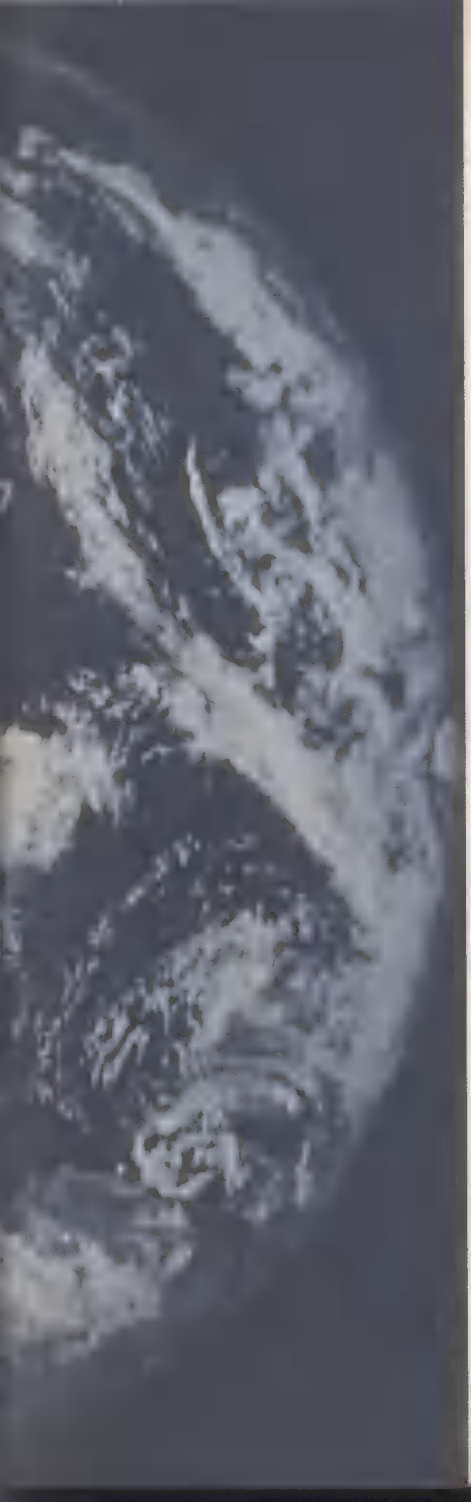
Infrared stars

Dyson himself says, "I don't regard infrared stars as being candidates for artificial objects. They appear where we know new stars are being formed." When a cloud of hydrogen contracts into a star, it gradually heats up, passing through room temperature at one stage.

Following this reasoning, Dr. P. M. Solomon, an astronomer at Columbia University, made some calculations that could wrap up the whole conundrum, if they stick. He showed how it was possible for a developing star to form OH, to give it maser action and at the same time radiate infrared.

Nevertheless, wheels are turning in other minds. At the Charlottesville meeting, a chart was presented showing a ring of five OH sources in W3 lying in almost a perfect circle. *The New York Times* reported, "One astronomer pointed out, half seriously, such a circle could be a 'community of Dyson civilizations.' "

EARTH SCIENCES



SCIENCE
DIGEST
SPECIAL

What's happening to our world

by James R. Berry

Some five billion years ago—still red with the heat of its own internal fires—a brand new earth hurtled through the thin clouds of matter from which it had accumulated.

In the frigid void, the plastic surface of the glowing planet began to "freeze," or crystallize, as its temperature fell below the melting point of rock (2000° F.).

Then, for eons, terrifying volcanic explosions ripped the newly-formed crust, spewing incandescent lava across the thin surface. As the crust solidified and grew, fed by the welling pressure of magma beneath it, the outer surface heaved upward in sprawling networks of wrinkles—like the skin of a drying apple. Vast cracks rent the hot crust. It leaved over itself; massive edges curled skyward in smoking, fiery upheaval to form primeval mountains.

Above the turmoil, a solid blanket

of jet black, soot-laden cloud surrounded the glowing orb like an opaque shell. Water vapor that condensed in the frost of space fell—only to evaporate again in the scorching atmosphere high above the surface. Finally, drops fell and did not sizzle away. The crust had cooled below the boiling point of water.

For thousands of years rain fell without stopping—great deluges of it, pouring in cataracts over volcanic ridges, carrying chunks of new rock from the peaks, tumbling them to valley floors. Rock shattered, rubbed against itself, powdered. Great rivers washed the debris to the bottom of newly formed seas. And, in the seas, life was born.

Earth still rumbles

As millenia passed, the violence subsided. But some of it still goes on. Old cracks shift, and the aging earth rumbles and trembles. Red magma still oozes from the fissures and occasionally there's a thundering display of explosive fireworks.

Just where do we stand today on this orb we call home?

Paradoxically, man—a recent addition to the planet—has managed to learn more about the solar system and galaxy in which he lives than about the platform under his feet. Recently, however, he has begun to look around him.

The situation is rapidly changing. The International Geophysical Year (IGY) of 1957-58 collected more data about earth in 18 months than in all history put together. Today, the pace—while more even—is accelerating and regiments of highly trained specialists are focusing their attention towards earth with batteries of sophisticated instruments.

Ours is a small planet, one of nine and among the first four that circle the sun. These first four planets—Mercury, Venus, Earth and Mars—are so similar in size, density and their spacing from the sun that they are collectively known as the terrestrial planets. The next four—Jupiter, Saturn, Uranus and Neptune—are huge compared to the terrestrials, not quite as dense as water on the average and increasingly enormous distances apart. They are known as the gas giants. Pluto, the outermost member of the solar system, probably isn't a planet. Speculations peg Pluto as a trapped comet or an escaped moon of Neptune.

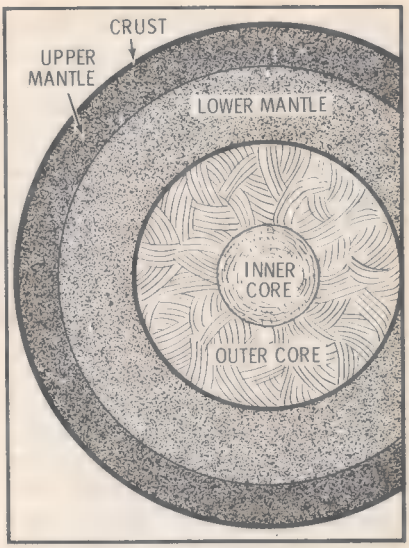
Early man could observe the heavens, and so astronomy became an amazingly exact science. But what lay a few hundred feet underground was relegated to myths. Active volcanoes offered one solid underpinning to these myths. Most all civilizations realized that earth's interior is hot. Explanations ranged from a hollow ball filled with flame to the location of hell's fire.

Seismology offered the first sound analysis of earth's interior. Earthquakes send out shock waves, some of which travel along earth's surface, while others plunge through

its bulk. Over the last 50 years or so, analysis of the deflection and speed of these waves showed that our planet has three principal layers. Only in recent years—within the last decade—have seismologists agreed on the composition of the innermost of these layers—the core.

They did have some clues to go on. Meteorites, thought to have been formed at the same time as earth, are often made of iron mixed with about 10 percent nickel. Astronomers concluded that earth's bulk, which is in the 4,200-mile-thick core, would be the same composition. Still other evidence came from seismic waves, whose speed through the core matched simulated waves through iron-nickel alloys. But only within the last five years has experimental proof—the usual scientific clincher—been available.

During 1964, at the University of Rochester, two geophysicists, Taro Takahashi and William Bassett, built a press that could exert pressures found 550 miles within earth, about 4.5 million pounds per square inch. Iron alone became denser as pressure increased. Adding nickel made iron progressively less compressible. When the team squeezed an alloy of 10 percent nickel and iron between the press' diamond anvils, they got a figure which they extrapolated to the 50 million psi found at earth's center. Their calculations corresponded to the density as measured by seismic waves and estimates of the earth's mass, proving the core is an alloy of iron and 10 percent nickel.



Cross section of the planet earth. So far man has direct knowledge only of the thin outer crust. Speculations about the nature of the core and mantle have varied.

The team discovered another important fact. The fantastic pressure exerted by earth's inner core, an area believed to be 1,600 miles in diameter, probably squeezes what should be a molten alloy into a *solid*. This, despite the fierce heat that causes the core to glow white hot.

But not so hot as once thought. In 1965, Prof. George Kennedy, working at California's UCLA, became suspicious of traditional estimates of earth's interior temperature. Until then, scientists used Lindemann's Law, a complex equation analyzing a substance's melting point in terms of its pressure. The conclusions from this law pegged

earth's core temperature at about 13,000° F., hotter than the sun's surface.

Kennedy plotted melting points of 50 or so materials against their densities at various pressures. The graphs he drew supported his doubts. The relationship, he found, is between melting point and *density,* not melting point and pressure. Since even a little nickel added to iron changes the alloy's density under pressure, former calculations varied widely from the mark. Kennedy's figures showed that earth's inner core is only 6,500° F. or so, adding further support that this area is solid. Notes Nobel Prize winner Willard Libby about this finding: "The profession must be full of asses. How could anyone be so stupid not to have seen it before?"

'Moho' bulges under oceans

Earth's mantle—a 1,600 mile thick band of rock ranging from 1100° F. near the earth's surface to a plastic 4500° F. deep within—surrounds the core. In 1910, a Serbian geologist named Andrija Mohorovicic found that seismic waves speeded up 20 miles or so underground. This speed change, he rightly concluded, was the boundary between the mantle and earth's outermost layer—the crust. Today, this boundary is simply called the "moho." Under some oceans, the moho bulges to within three or four miles of the ocean floor. Typically, the crust is 20 to 40 miles thick.

A prime reason for seismologists' interest in earth's crust is the prevention, or at least warning, of earthquakes. Inadvertently, specialists are getting a rare chance to observe the birth of earthquakes.

In 1962, the U.S. Army dug a well 12,000 feet deep near Denver, Colo. By 1966, the military had dumped 160 million gallons of poisonous waste water from a chemical warfare plant into the hole. During that year the Denver area, which was as earthquake free as New York, was hit by slight tremors. During 1967, the shocks become shudders, then severe shakes that damaged a few homes. Seismologists pinpointed the disturbances' focus as the well. Today, the Denver area is ringed with seismographs that record every earth tremble.

While experts figure out what remedial action to take, they may yet get more spectacular effects to study. Many specialists predict that the strain of the water's weight on bedrock will result in a severe earthquake this year or next.

Other geophysical studies deal with different characteristics of earth—its shape, for instance.

Contrary to popular belief, neither Columbus nor any other educated man, since Pythagoras lived six centuries BC, believed the earth was flat. But ancient scholars did make a mistake about its shape. They believed that earth was a perfect sphere.

The first hint that it wasn't came in 1672 when French explorers in

Most people think the earth is round.
It isn't, it is very slightly pear-shaped.

Guiana, South America, noticed that pendulum clocks lost 2.5 minutes a day near the equator. Sir Isaac Newton used this fact to prove that earth bulged at its equator and flattened at its poles. In 1948, the English astronomer Sir Harold Jeffreys cranked the moon's orbital irregularities in with earth's precession rate and got a formula that showed the planet is 30 miles shorter from pole to pole than through its equator.

This figure stood until the satellite era. Observations of unexpected orbital wobbles by Russia's Sputnik II and the United States' Explorer I and Vanguard I revealed that earth is actually flattened by 26.6 miles. Practically, the difference is slight. But it sent geodesists, who consider a measurement error of 10 yards in 1,000 miles a calamity, into a scramble for more precise figures. It was the satellite era that led to today's picture of the geoid—earth's sea-level shape.

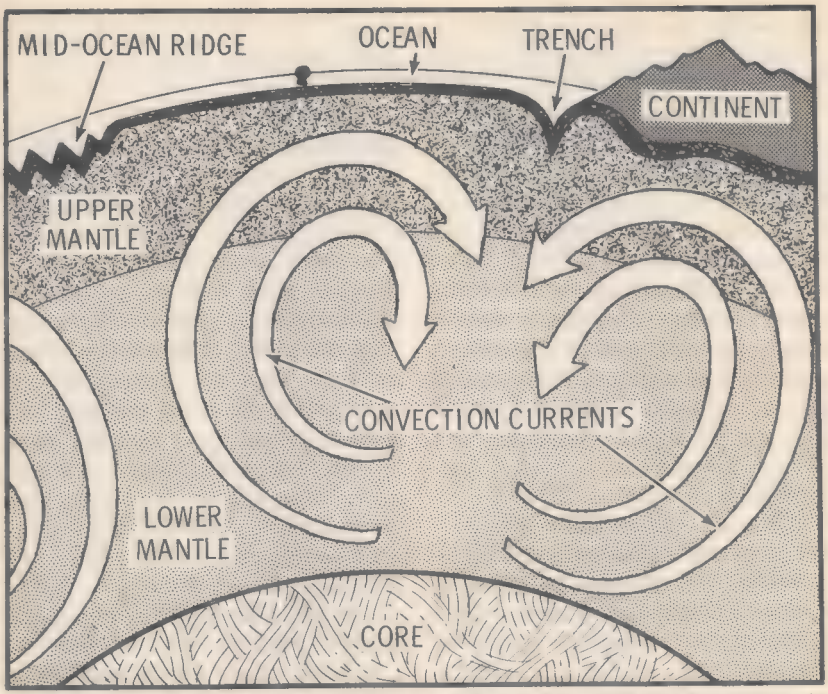
Vanguard I also showed that the geoid isn't merely flattened at the poles. Its orbit proved that the South Pole bulges inward by 120 feet, as though dented by some monstrous kick and giving earth a slight—very slight—pear shape.

Over the years, analysis of scores of satellite orbits indicates that characterizing earth's shape as a pear is like describing a voluptuous woman as a biped. A recent geoid map made by Dr. William Kaula of the University of California is a phrenologist's dream. For example, at the equator the geoid's height in the Congo, on the average, is zero—3,963.21 miles from earth's center; the average equatorial diameter is 7,926.42 miles. Traveling eastward on the geoid, an imaginary trip since mountains block the path, one reaches a point south of India where the geoid dips 260 feet. At a spot above Australia's east coast, the geoid rises 220 feet, 480 feet further from earth's center than when south of India. Other prominent bumps on the geoid are centered in western Europe, near the South Pole and off California's coast. The exact cause for these dips and rises remains to be discovered. But perhaps it's no coincidence that the geoid's biggest irregularities correspond to major earthquake areas.

Continental drift

One important theory about earth's surface holds that the continents have drifted apart to form today's land configurations. In 1908, a team of explorers led by Sir Ernest Shackleton tried to reach the South Pole. They didn't make it, but they did find fossilized leaves and wood, and beds of coal, proving that Antarctica had once basked in a tropical climate.

This discovery revived the con-



The convectional flow of hot material within the earth's mantle is what causes the major changes on the crust, according to one theory. Upward flow forces the crust apart forming mid-ocean ridge, and pushing continents apart. Downward flow forms faults and trenches, and squeezes adjoining land into mountain ranges. The convection currents are used to explain the force behind controversial continental drift theory.

tinental drift theory, whose champion was the German meteorologist Alfred Wegener. During the late 1800s, Wegener noted that similar vegetable and animal life had lived on continents not connected by a land bridge. This and other observations convinced him that the continents were once joined together. The idea faded, then revived, until it is widely accepted today. (See *Science Digest*, January 1968, for detailed explanation of continental drift. See page 16 of this issue for new drift theory discovery.)

Until recently, man knew almost as little about the atmosphere above him as the earth below. What *has* been known is that the first 50 miles above earth contain 99.999 percent of all atmospheric gases and is a mixture of 76 percent nitrogen, 23 percent oxygen and one percent argon and other samples. If our planet were represented by a six foot-diameter ball, this part of the atmosphere, called the homosphere, would be a mere half inch thick.

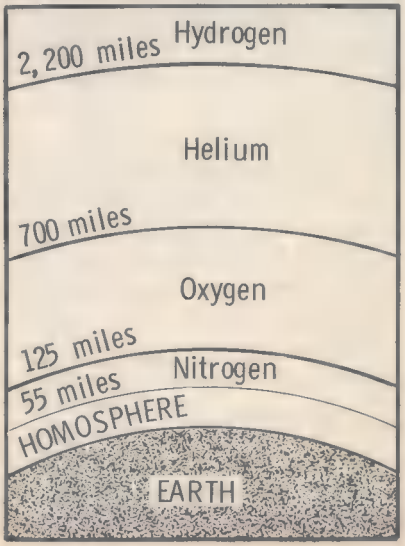
The homosphere was once considered a relatively simple gas mixture with some turbulence such as hurricanes and tornadoes. No more. It hasn't been easy exploring the homosphere, and many gaps in meteorologists' understanding exist today. But through the use of specially designed balloons that can rise 20 miles or so before splitting, and thousands of rocket probes that release batches of chaff that can be tracked by radar, meteorologists have gradually pieced together the air densities, speed and direction of currents, and temperatures at various heights.

The homosphere is dominated by two wind cores. The first, the jet stream, was found during World War II. This current blows along at an average 65 miles an hour from the west and is, on the average, eight miles high. About 30 miles above earth, meteorologists discovered another wind core, one that blasts along at 160 miles an hour. Unlike the jet stream, this swift moving core changes direction, blowing from the east during summer and from the west during winter. These directions are probably reversed for the southern hemisphere.

The origin of these two rivers of wind is heat. As the equatorial regions of earth warm up, giant quantities of heat are released into the atmosphere. This heat is carried toward the poles primarily by enormous atmospheric eddy currents called cyclones and anti-cyclones Because air spins faster at the equator than at the poles, cyclones carry with them not only heat, but momentum. It is this motion that is transformed into the east-bound jet stream, and through a much more complicated and still dimly understood process to the air core above it.

Above the homosphere lies the remaining atmosphere, which is known as the heterosphere. Until recently, meteorologists believed that the heterosphere consisted of a layer of hydrogen over a band of oxygen. In 1962, scientists had a chance to compare meteorological data from the IGY at the International Space Science Symposium in Washington. Their conclusions,

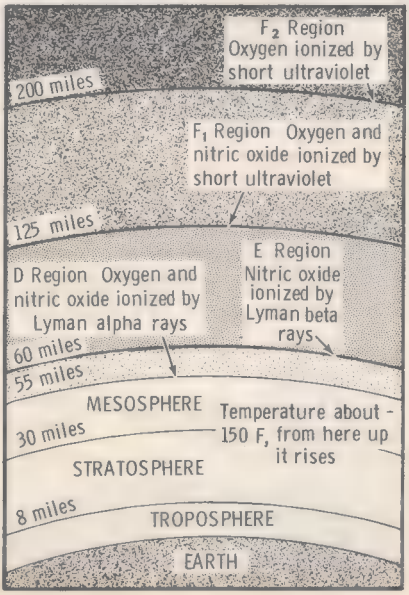
The envelope of gases that surround the earth have within the last few years been revealed to be quite complex. In the heterosphere (above 55 miles) the gases are sharply divided into different layers.



since backed up by rockets fired high into the atmosphere, close analysis of atmospheric drag on Echo satellites and radar analysis of these regions, offered a comprehensive picture of what our outermost atmosphere looks like.

Unlike the homosphere, the heterosphere is neatly divided into several gas layers. The first after the homosphere is a band of nitrogen 70 miles thick. This is followed by a 575-mile wide layer of oxygen, which yields to a layer of helium. At 2,200 miles, this is followed by a rarefied layer of hydrogen. At about 22,000 miles from earth, this hydrogen thins out to disassociated atoms.

Not only do the gases of the heterosphere exist in bands, the bands have subdivisions where photochemical reactions take place. The effect of these reactions on surface conditions is only vaguely known.



Meteorologists have also discovered distinct subdivisions within each layer where many photochemical actions take place. Some of these reactions are important. The formation of nitric oxide ions about five miles into the nitrogen band—an area known as the E region—reflects radio signals back to earth during nighttime. In several other regions, photochemical actions distribute, store or transfer heat—a process physicists feel probably influences our weather. Just how remains to be discovered.

Among the atmospheric mysteries remaining to be solved is the nature of the boundary between the homosphere and the heterosphere. Geophysicists are certain this interface is the scene of important action. But balloons can't reach that high and satellites must orbit higher. That leaves fleeting looks at this 55 mile-high region with rockets, hardly enough to satisfy scientists.

Atmospheric gases are only a part of earth's outermost perimeter. Also girdling our planet is the magnetospere, a magnetic field whose origin can probably be traced to the earth's core.

Geophysicists suspect that convection currents of molten iron plus the planet's spin generate a magnetic field. That earth *has* a magnetic field has been known for centuries. But what wasn't known until satellites probed the heavens was that this field is a vital shield that

The earth's magnetic field forms a vital shield that wards off high energy radiation.

wards off high energy radiation.

In 1958, a tiny satellite called Explorer I began measuring cosmic ray intensity with a geiger counter. During part of each orbit, the counter blacked out from radiation readings too intense to register. Other satellites, ones with improved instrumentation, found that this thick radiation centered in two distinct belts that surround earth like invisible tires. These are the Van Allen radiation belts. In 1961, yet other satellites filled in details about the nature and composition of these belts.

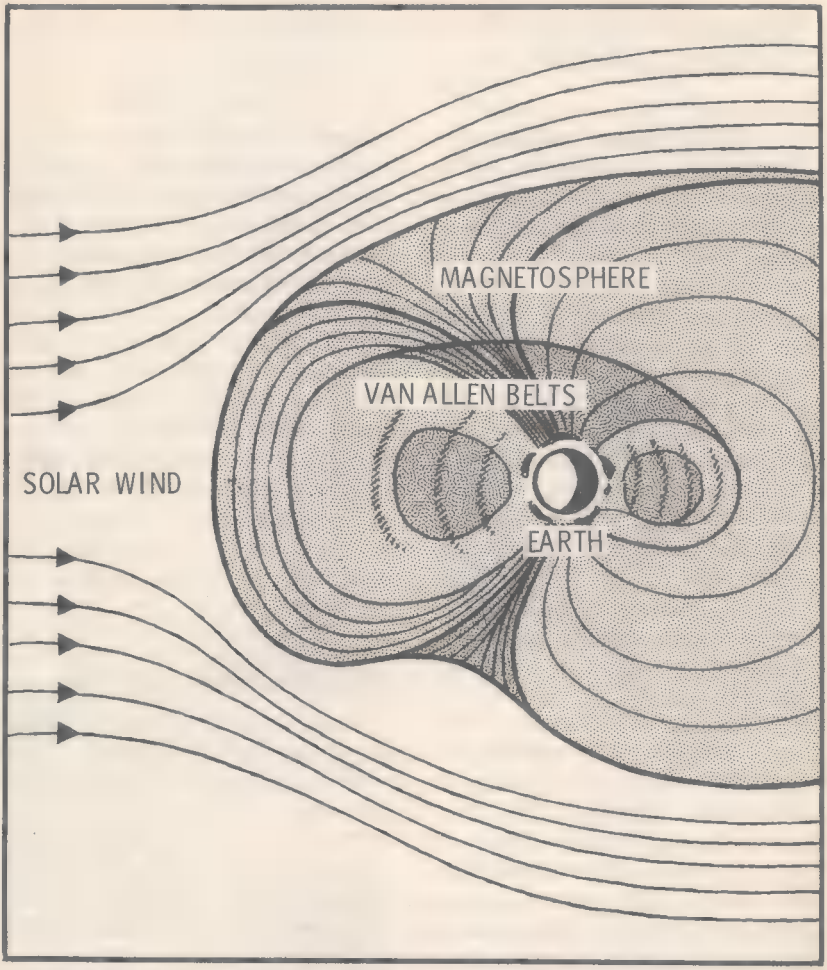
The sun blasts out a rain of high energy particles that stream toward earth at a peak speed of three million miles an hour. This solar rain compresses earth's magnetic field into an elongated tear whose blunt end comes within 40,000 miles of the planet's surface. The long, streamer-like tail trails behind as much as four million miles and waves in the solar breeze. During especially powerful solar storms, the magnetic field is squeezed to within 25,000 miles of earth's surface. The boundary where solar wind meets magnetosphere is amazingly precise—a mere hundred miles thick. This boundary is thought to be the origin of magnetic storms and the aurora, sheets of light seen at polar regions.

Some of the sun's radiation spirals through the magnetosphere, finally becoming trapped in one of the two Van Allen belts. The first radiation belt arches 2,000 miles above the magnetic equator and is filled with high energy protons. The second belt, made of high energy electrons, girdles the magnetic equator 10,000 miles above earth. The amount of matter in these two belts is amazingly small—a few grams. "But that doesn't give you any idea of the tremendous energy involved," explains James Van Allen, who designed the instruments that first explored the belts. "And in space, energy is what is in command."

Electrons, protons separated

Once the nature of the belts became established, physicists could work out how earth's magnetic field segregates electrons from protons. In 1966, Van Allen proposed that the combination of solar wind blowing against the magnetic field and the dynamo effect of earth's spin produces an electrical potential of 50,000 or so volts across the magnetosphere. The positive charge centers on the side facing the sun and attracts protons. The negative charge is on the evening side, and pulls in electrons.

The magnetosphere and the Van Allen belts haven't always had today's configuration. In 1906, a French physicist named Bernard



The earth is surrounded by a field of radiation called the magnetosphere. This field protects the earth from full exposure to the rain of high energy particles that are constantly being blasted out from the sun. Some of the solar radiation that gets through may be trapped in the Van Allen belts, high intensity zones of the magnetosphere. If the magnetosphere dimmed, earth would be hit by dangerous particles.

Brunhes measured the magnetic strength and polarity of many volcanic rocks. In some, he found that the polarity was the exact reverse of today's magnetic field. From this discovery he suggested that earth's magnetic field had once reversed itself. No theory could account for

such an event, and Brunhes' idea was laughed out of respectability.

But drillings in the last five or six years have shown that such reversals not only take place, but are comparatively frequent. A recent expedition of the Lamont Geological Observatory drilled hundreds of sedimentary cores from the North Pacific ocean. Geologists then examined the layers of each core for magnetic polarity and fossils. The study, plus others, showed that earth's magnetic field has switched polarity nine times in the last 3.6 million years.

Magnetic reversal

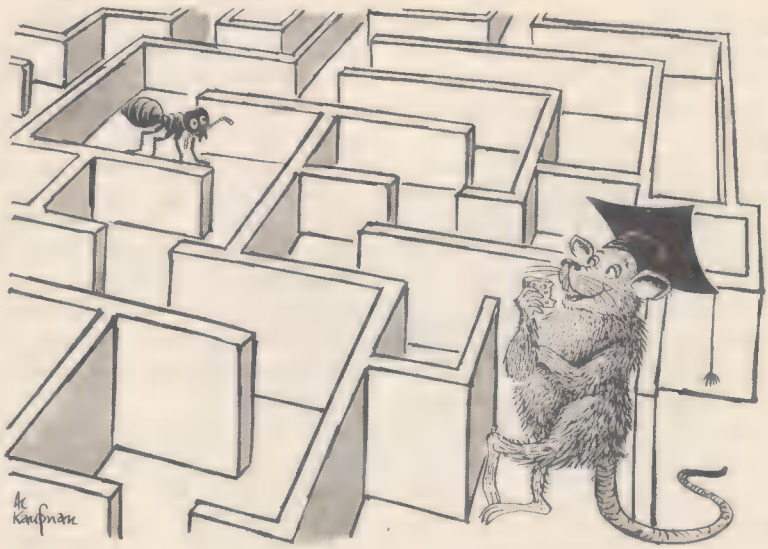
The exact mechanism responsible for such switching remains obscure. But Dr. Keith McDonald of the U.S. Environmental Science Services Administration offered one possible explanation last January. According to McDonald, a research physicist, heat from earth's solid inner core vents into the molten core near each of the poles, upsetting normal turbulence. As a new pattern of currents emerges, earth's magnetic field changes polarity. Whatever the cause, a magnetic reversal is swift on a geological timetable. A complete switch takes a mere 5,000 years.

Scientists paint a gloomy picture for life during such a changeover. At midpoint, earth's magnetosphere dims to a scanty five or six percent of its normal strength. Cosmic rays, which the magnetic lines of force trap or ward off, pelt earth's surface unmercifully, resulting in death or mutation of life forms. The Lamont Geological Observatory analysis of Pacific cores revealed that soon after a magnetic reversal 2.5 million years ago, new species of algae and protozoa suddenly appeared. These life forms lived almost unchanged until the last reversal 700,000 years ago. At this point, many of the life forms disappeared; others mutated into new forms, and even new species of life appeared.

One such new species was homo erectus, the precursor to homo sapiens—man. Paleontologists feel too little evidence links the advent of homo erectus to magnetic reversals, at least so far. But one thing is sure. Since man's appearance, he hasn't lived through a change in magnetic polarity.

Cosmic ray bombardment

His turn may be coming. Earth's magnetic field has decreased by 15 percent since 1670 AD. A study made by the U.S. Coast and Geodetic Survey suggests that the magnetic field will have all but completely faded by the year 3991 AD. For a bracket of 500 years around this date cosmic rays will bombard earth virtually unhampered. And that, all experts agree, will cause at least some mutations and probable extinction of some life forms—possibly man. "I don't want to be an alarmist," remarked one Lamont geologist, "but man may go the way of the dinosaurs."



Intelligence of invertebrates

Even a simple maze is complex for the ant, who, though smart for an invertebrate, falls far below a medium intelligent mammal—the rat.

by Barbara O'Connell

THE *Formica* ant in the maze ran into one of the corridors, hesitated, then ran out. It entered another corridor and ran along it to an opening which led to food. On the next run, the ant turned into the same wrong corridor, but only proceeded a few steps before it ran out and into the correct corridor. Eventually, the insect entered only the correct corridors. But when the maze was turned around and the ant had to run it from the opposite end, it seemed to remember nothing at all.

A rat ran the same maze. On his second trial, the rat had already eliminated some of the blind alleys. He quickly dropped others in later runs. When the maze was reversed, the rodent learned the new pattern in much less time than the old, indicating he'd remembered his former learning.

Observing the experiment was Dr. T. C. Schnierla of the American Museum of Natural History. One of the many scientists now investigating invertebrate behavior, Dr. Schnierla wanted to see how the learning process of the ant, which is near the top of the invertebrate intelligence scale, compares with the performance of the rat, which is about half-way up the mammal intelligence scale.

The ant not only learned the maze much more slowly than the rat, Dr. Schnierla noted, but it learned it in an entirely different way. The insect's learning seemed to be divided into three distinct stages. In the first stage, it simply accustomed itself to the maze. In the second, it eliminated wrong turns. Finally, it coordinated the correct turns into a smooth run. The rat, on the other hand, showed sudden bursts of improvement with no noticeable stages.

The implications? For an invertebrate like the ant, even a simple maze is a complex feat, learned in a plodding manner in which mastering one stage is a condition for learning the next. The insect doesn't get around to organizing its responses until the third stage of learning. Once it masters the maze, it can't repeat its responses except in an identical situation. There's no carry-over except of the most general kind.

An invertebrate can never be as smart as a mammal, Dr. Schnierla points out. Even the smartest invertebrate doesn't quite measure up to the most stupid mammal. It's a matter of equipment. An ant's brain is complex for an invertebrate but it contains few of the association neurons that permit an animal to organize its responses. Instead, it has numerous inlet and outlet neurons that fix it to specific motor and sensory responses. A rat's brain, in contrast, contains many association neurons.

Because an invertebrate brain is fixed to specific responses, you'll see these creatures persist in stereotyped behavior that is actually detrimental to them. Ants, for example, rear enemies in their nests who eat the ants' larvae. A bee will continue to throw honey into a cell for the larvae even when all of it falls out through a hole onto the floor. A blinded octopus will strain to lift an object so big it can't get its arms around it.

Army ants not so smart

While invertebrates are considerably less intelligent than mammals, as a group these backboneless creatures show abilities that range from the simple reaction of the starfish to the complex achievements of the ant or bee. The latter two have the most highly developed nervous system among the invertebrates. Not all ants or bees are so smart. If you put an army ant in a maze, it will simply wander around "until you run out of time," according to Dr. Schnierla. Fixed on smell to an extreme degree, army ants will only react to the odor of their col-

ony. In evolution, army ants are millions of years behind an ant like *Formica*.

Below *Formica* and an intelligent bee, like the honeybee, in the invertebrate intelligence scale, scientists rank other arthropods (a class that includes insects, spiders, crabs and lobsters), then mollusks (octopuses, snails and clams), and earthworms. The flatworm, or planarian, is considered probably the lowest invertebrate that can learn. Near the bottom of the scale are placed creatures like the starfish, which can't learn even a simple turn.

Planarian outsmarts starfish

Researchers know that they can't expect much of the starfish because it doesn't have anything that could be called a brain. The planarian is one step up because it has a rudimentary brain consisting of a centralization of ganglion cells at one end of its body. The relatively large brain of the octopus dominates the animal to a greater extent than in the lower invertebrates. In the ant or bee, the brain plays a controlling part in numerous local activities.

Invertebrate research has concentrated to a large extent on the more intelligent animals, such as the insects. In recent years, however, some of the most exciting invertebrate research has been performed on lower invertebrates. Figuring in many of these tests has been the planarian, a worm-like aquatic creature that Dr. James V. McConnell of the University of Michigan calls the "most obstinate, ornery, difficult animal to work with that one could imagine." (See Can memory be transferred by injection? *Science Digest*, May '68.)

Scientists working at the *Stazione Biologica* in Naples, Italy, are applying an ingenious set of learning and memory tests to the common European octopus, with some surprising results. The octopus, they've found, is a lot smarter than it looks, but it has some big gaps in its learning abilities. On one hand, the creature readily learns to recognize different geometrical figures by sight and to discriminate between different cylinders by touch. A normal octopus will choose the correct turn in a tank to reach a tasty crab and even creep out of its den to greet its keeper.

On the other hand, the octopus reacts to some aspects of training in a way that seems peculiar to vertebrates. If you present a blinded octopus with cylinders that are equally rough to touch but that have different patterns of roughness, it can't tell the difference between them. It will treat a bundle of rods stuck together as if the bundle were the size of each component rod. An octopus can't seem to judge weight at all, nor can it recognize differences in shape by touch alone.

Dr. Martin J. Wells, one of the British biologists who has been investigating the octopus, thinks that its "failures" arise from a lack of

The invertebrates' decentralized nervous system allows for independent "learning" by various limbs.

sensory input to the learning part of the octopus brain. When an octopus grasps an object with its tentacles, for example, no information on the object is returned to the brain. The brain has no idea what the tentacles are doing.

With a decentralized nervous system like this, the blinded octopus treats size, weight and shape as textural problems. It classifies the roughness of cylinders on the basis of the distortion imposed on the individual suckers that line its tentacles. It judges size by the distortion of the 10 or 20 suckers in contact with an object. Shape is treated in the same way. A normal, unblinded octopus uses vision to control its general approach to its prey and local tactual and chemical stimuli to control the responses of its arms. The two approaches, however, never cooperate.

The implication of this kind of nervous system, Dr. Wells points out, is that an octopus can never learn to make skilled movements, since it can't learn to make small modifications in the movements.

A further implication of the decentralized nervous system shared, in greater or lesser degree, by all invertebrates, has been emphasized by the research of Dr. G. A. Horridge of St. Andrews University in Scotland. Dr. Horridge trained locusts to lift their legs in response to a shock. Then he severed one leg. The severed leg responded to the shock in the same way as the leg attached to the insect. The limb, in other words, is so independent that it can "learn" by itself. He performed a similar experiment with a cockroach and the same thing, he says, can be done with any large insect.

What is the advantage of a decentralized nervous system such as this? A cockroach, when it's trying to escape a descending foot, can move more quickly because the message to flee doesn't have to stop over in the roach's brain as it would in a vertebrate.

Some advantages

A honeybee can get more nectar by using only sensory clues specific to the target and ignoring others. After an ant has learned to feed at one place, it can switch to learning another feeding place without any interference between its responses to the two sites. A lower invertebrate like the planarian can be cut in numerous pieces and each piece will regenerate itself and become a complete animal.

Still another possible advantage of the invertebrate nervous system is indicated in the comparative study of the rat and the ant carried out by Dr. Schnierla. After both animals had learned the maze, he changed the situation so that the

rewards were offered arbitrarily. Many of the rats that had run the maze so well in earlier tests now were unable to run it at all. Confused by their former training, they grew excitable as they approached the junctions where they had to choose a path. They would stop suddenly, or gallop around wildly. When the alternative choice points were painted different colors, the rats manifested even more extreme behavior. Some threw themselves against the ceiling. Others froze in rigid positions. A few of the animals killed themselves in their frantic leaps. The same behavior continued in their cages. If they were put back in the maze even a month later, they reacted more violently.

The ants, remembering nothing of their former learning except a general familiarity with the maze situation, reacted with much less disturbance to the arbitrary rewards. They were tense, particularly in eating the reward, but not to the point of not being able to run the maze.

Apparently, Dr. Schnierla points out, the ant can't become neurotic because, unlike the rat, it's incapable of dealing with two contradictory adjustments simultaneously. The rat has trouble precisely because it's capable of responding simultaneously to contradictory possibilities. For the more intelligent animal, the result is a nervous breakdown; for the simpler creature, only nervous tension.

Experiments like these, scientists think, not only tell us much about invertebrates themselves, but add to our data on learning, memory and other processes about which we still know very little. In the relatively simple organization and behavior of the invertebrates, we may find the answers to some complex questions, such as how we learn and remember.

"It's the new math, I guess: multiply by dividing."

K.F.S.

The movie, "The Snake Pit," symbolized the horror associated with state mental institutions. But progress is being made, and with it, a hopeful end to all snake pits.

Farewell to the snake pit

by Flora Rheta Schreiber and Melvin Herman

On the 93rd day of his fourth year as a psychiatric patient at the Eastern State Hospital in Knoxville, Tenn., George C. decided he could make it in the outside world. He announced his decision, signed himself out and got a full-time job. Six months later, he showed every sign of succeeding in his new adjustment to home, work and society. Yet less than a year before he was one of a group of hard core patients who faced life-long confinement in the state hospital.

George's remarkable change is the fruit of a radical new program undertaken by Dr. Cecil Mynatt, superintendent of the hospital. Dr. Mynatt divided hard core patients into two groups. All of the patients had been in the hospital for at least three years. Dr. Mynatt arranged for intensive therapy for one group of 75. No efforts in staff time or energy, no possible resources of psychotherapy or of therapeutic

milieu were spared to make these 75 well. For the other group, also consisting of 75, opposite techniques were used. The professional staff was withdrawn. The remaining staff was told: "Just let them make a home for themselves here."

The patient's decision

In this spirit, the patients held meetings, set up their own community life, developed their own daily schedules and in general ruled their own house. When a patient thought he was ready, he could try to make it on his own in the once frightening outside world.

At the end of six months, three patients in the group that received intensive psychotherapy and other professional benefits of the hospital, were well enough to be released. Of the second group, however, 22 had declared themselves well enough to be discharged and to resume life on the outside. Some found full-time jobs. None has been returned to the hospital.

Dr. Nat Winston, Tennessee Commissioner of Mental Health, says frankly: "There are no conclusions possible at this point, but there are a great many long range implications. Some of these 22 patients, of course, may have to be readmitted within a year. We just don't know. But the indication is that the patient who doesn't feel pushed or challenged may make a better adjustment than one who does. Perhaps the self-reliance the 22 felt counteracted the negativism that was at the root of their sickness. Their efforts to make it on their own may have counterbalanced their earlier efforts to pull out of the society." Dr. Winston added: "These patients developed pride for both themselves and their unit. They developed their own government with rules that were sound. They even developed their own form of group therapy."

In any psychiatric group, this handling of patients would be termed daring, but a new day is dawning for state hospitals. They are attempting to shed the snake pit image and join the call for new approaches to the problem of mental illness.

A new outlook

A decade ago, Rochester State Hospital in Rochester, Minn., was a state hospital in the old tradition. Not any more. Patients are no longer scrubbed and shampooed on admission as though they were assumed to be unclean as well as ill. No longer does an inadequate, non-professional staff care for backward patients.

Today, Dr. Edward M. Litin, head of psychiatry at nearby Mayo Clinic, rates Rochester State as excellent, and its patients, treated with dignity by a professional staff, return in increasing numbers to the

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Miss Schreiber is an award-winning writer on psychiatry; Herman, the Executive-Secretary of the National Association of Private Psychiatric Hospitals.

The first progressive step at a Minnesota hospital was getting rid of antiquated traditions and rules.

community they once had to leave.

How did the transformation come about? Dr. Francis A. Tyce, the hospital's medical director, staged a professional revolt against three hospital traditions. One is the constantly diminishing freedom of action physicians have had with their patients. Another is the rigid admission and discharge systems which have made it as difficult to get into a state hospital as to get out, and which have turned patients into captives of their own passive dependence on hospital routine. The third is the inability of the state hospital, whether Rochester or any other, to attract personnel of outstanding caliber.

Dr. Tyce's first order of business was, as he puts it, "to take administrative steps to free patients from the restrictions, often humiliating and sometimes purposeless, that were termed routine hospital procedures." Categorically the doctor said, "Many of these rules existed for the benefit of the staff rather than the patients."

In 1960 every department of the hospital began a search for new ideas. One doctor, delegated as a circuit rider, visited the agencies that refer patients to the state hospital. The word he spread was that Rochester State preferred voluntary patients to committed ones. Rapid changes followed not only in admission procedures and other rules, but also in personnel and medication. In time the new ideas rubbed off both on old staff members and on long-term patients who, in the atmosphere and under new treatment methods, felt new hope.

Even physically, the hospital, which was opened in 1879, has undergone a metamorphosis. Its original buildings have been completely replaced by modern two-story structures housing patients in single or double rooms. No building accommodates more than 200. Intensive treatment methods and the new drug therapies, morever, have sent many patients home. This has led to the availability of more beds.

Hospital 'campus'

With these innovations in hand, Dr. Tyce began to dream of placing other health facilities on the campus alongside the hospital. By doing so he believed that he could not only remove the age-old stigma connected with admission to state hospitals, but also contribute to the training and experience of the psychiatric residents at the Mayo Clinic. When he first approached day activity centers, nursery schools and other groups to become part of his campus, he met with strong resistance. These groups protested that, by joining Dr. Tyce's campus, they would not only lose their

Revolutionary experiments are yielding excellent results, but severe personnel shortages still exist.

autonomy, but would also bear some of the stigma of the state hospital.

Yet just a year after Dr. Tyce had drawn up his idealistic blueprint, the campus was a reality. Today that campus houses, in addition to the state hospital, an outpatient clinic, a day activity center of the Mental Retardation Association for Mental Health, a Center for Alcoholism, a sheltered workshop, a day hospital for just 40 patients and even a demonstration day-care nursery.

Attitudes changing

This nursery, which 300 children attended in a six-month period, provides a five-day a week service not only for the children of patients at the day hospital and the outpatient clinic, but also for the children of hospital volunteers.

The Rochester State and the Eastern State programs are but two of the revolutionary experiments that are converting state hospitals from the snake pit of fact and legend into institutions that give promise of salvaging patients, who in an earlier era were lost to themselves and the world.

Seven years ago the book, "Action for Mental Health," the final report of the Joint Commission on Mental Illness and Health, composed of some of the country's leading psychiatrists, said, "The state hospital continues to occupy its historic position in the forgotten corner of medicine."

The contrast is further highlighted by the experiences of Susan Van Beneden and Thomas Wedekind, students at Colby College, Waterville, Maine, who, while serving for a month as volunteers with the recreation therapy department of the Cleveland (Ohio) State Hospital, kept a diary. "Looking back on the past month," these students report, "we find that many of our attitudes have changed about mental illness and its treatment in a state hospital. When we first arrived at Cleveland State, we expected anything and everything; we had prepared ourselves for the worst. We had told ourselves that the hospital existed as an artificial world, and that the comparisons with our 'real' world would quickly be apparent.

"However, we soon realized we were not dealing with lifeless comparison factors from a textbook, but rather with an organization consisting of real people . . . We soon observed seriously that staff and patients are all individuals, just as people outside the hospital are . . . We also realized that the hospital world and the outside world are not so different. At first we had thought that the two worlds could never be integrated, but we began to see

that integration is the only way to break the chain of endless, aimless days and nights of hospital life."

In the U.S., the average daily expenditure per patient in a mental hospital has more than doubled since 1955, but it is still grossly inadequate. As a direct result, the ratio of full-time hospital employees to patients has also doubled—although there are still alarming shortages of professional personnel. Nearly a third of the country's state hospitals have less than five psychiatrists, and 21 have none. With the help of a great increase in research grants, even the worst states, however, are now showing marked progress in their state hospitals. Across the country—not only in states like New York, Connecticut, California and Massachusetts, which lead the nation in the quality of their psychiatric care, and in the special instances cited in Minnesota and Tennessee—the old snake pits are vanishing.

What about your own attitude towards these hospitals? Let's test it. Ask yourself the question! *A state mental hospital is most like a:*

General Hospital
Prison
Boarding House
Nursing Home

If your answer was a prison, you agree with 25 percent of the public, according to the Public Image of Mental Health Services study under the joint auspices of Columbia University and the New York City Community Mental Health Board.

Now ask: Are state mental hospitals too big to give proper care? If your answer was yes, you agreed with 50 percent of those questioned.

Are they usually snake pits?

If your answer was yes, you agreed with 24 percent of the Columbia University sampling.

Even if most patients do not get better there, are state hospitals needed because they do a job of protecting the community?

A yes answer puts you in the class with 83 percent of the respondents.

Even though the questioners recognize the shortcomings of state mental hospitals as a whole, it is only a relatively small group that classifies them as snake pits. Can we perhaps begin to say farewell to the snake pit?

"I wish, Miss Harkins, you'd stop referring to my practice as 'the old skin game'."

NEW FOR INDUSTRY

Sub-micron filter, similar to the one that makes draught beer in bottles, now will be used to sterilize water for manufacture of microcircuits. Filter and cartwheel support are made by Cox Instrument, Detroit.

Bank of gas infrared heaters for outdoors provides warmth for people and objects—not air. All-ceramic burner will last 10 years. Cercor Products Department, Corning Glass Works, Corning, New York.

No hands needed to run London Transport's new automatically driven trains. Once doors are closed and twin start buttons pressed, the train will respond to coded impulses transmitted through tracks.

Baby radar transmitter (below) is portable, inexpensive and can be held in one hand to detect moving objects. It was developed by Great Britain's Royal Radar Establishment. Range is about 200 yards.

This xenon bulb has been developed to replace carbon arcs in motion picture projection systems. It will cut present cleaning needs. By Strong Electric Corp. and Westinghouse Corp. in Bloomfield, N. J.

Right: This fully automatic pipe layer is designed to cut smoothly through up to nine feet of ground. It will be introduced this year by Hudswell Yates Development, Ltd., 408 Oakwood Lane, Leeds, England.

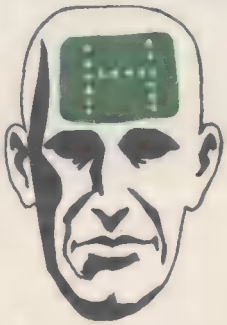
Continuously measuring rainfall rate gauge is being used to study rain density effects on microwave transmission. Data is relayed over telephone lines, then recorded on magnetic tape. Bell Telephone, Mountain Avenue, Murray Hill, New Jersey.

MEDICINE

Blind can be wired for sight

by Arthur J. Snider

SCIENCE has the technical knowledge to make the blind see by stimulating the brain through electronic means, says Dr. Wendell J. S. Krieg, Northwestern University anatomist. He believes a set of light-sensitive cells—such as the "electric eyes" that open doors—could be worn on top of the head. These would be connected to wires which in turn would be carried



through minute holes drilled in the skull and affixed permanently to that part of the brain where vision is interpreted.

For example, an H-shaped group of light spots could be trained onto the head apparatus and would be seen as an "H" in the mind's eyes. It would thus be possible to send a sequence of letters, spelling out messages. The blind person would see them in the manner that news flash signs are read in Times Square.

From this small start, the system could be extended so that animated cartoons could be viewed. These would be similar to the animations seen in large electric signs. Then, at a later time, the patient could perceive positions of windows, doors and approaching objects, particularly in his own home, which would be wired with lights directed from different angles. The photocells could be arranged at any desired angles.

"He would be enabled to move more rapidly and safely and to throw away the white cane, which is little more than a tradition or a warning," said Dr. Krieg.

As for the apparatus to be worn on the head, Dr. Krieg insists it wouldn't look any funnier than some hats worn by women today.

He says the basic knowledge to carry out such a program for the blind is already at hand. The brain areas are sufficiently mapped and the system for stimulating the visual portion of the cortex is well known. Needed only is the desire of society to carry out the project. It would take considerable funding and probably the establishment of an electro-neuro-prosthetic institute.

The same principle could be used to help the deaf to hear. This is particularly important in children either born deaf or those who acquire deafness in early infancy. They never learn to speak because they cannot hear the sounds needed

to imitate speech. Similarly, electrical stimulation of muscles made useless by injury to a nerve or the spinal cord could restore movement.

"It is a comparatively easy matter with a myograph to analyze the exact time sequences of all the muscles of the limbs while walking," the anatomist says. "By playing such a record on a stimulator connected to the proper muscles, each muscle could be made to contract at the right time and the result would be normal walking."

Change brings depression

Doctors are seeing more depressed people than ever before, says the editor of the *American Journal of Psychiatry*. The Vietnam war, the youth revolt and racial unrest are all contributing, but the most important factor is the "phenomenon of rapid change."

"We are moving from one era to another era in a matter of years," comments Dr. Francis J. Braceland. "At the beginning of this decade, for example, we didn't have a war, a hippie movement or anarchy on our streets. We are not able to adjust fast enough. Change demands new adaptive reactions. The more rapid and profound the environmental changes, the larger the number of people who cannot adapt rapidly enough. The result is often a depression."

Change always has been part of the lives of men, but the present order of change is completely different from anything ever seen before and anything our ancestors ever experienced," Dr. Braceland says.

As people grow older, they tend to resist change, he says, adding: "Anger, which should be directed at the causes of change or the producers of stress is held in and directed against one's self. Here, again, depression results."

Fortunately, it is possible to treat this kind of illness successfully. About 90 percent of those afflicted return to their homes and jobs in six to eight weeks. Decades ago, the outlook was bleak for this group. Sixty percent went on to chronic illness.

'Rock' physically unsound

An ear specialist, the father of a teen-age daughter, has found that a rock band can generate a noise level close to that of a jet aircraft.

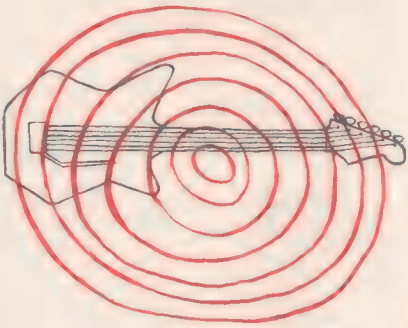
Dr. George T. Singleton, head of the division of otolaryngology, University of Florida, tested his daughter and nine other teen-agers before and after a party and discovered a measurable hearing loss in all 10.

The loss was regained but a ringing in the ears persisted for another 18 hours. Most of the teenyboppers admitted being fatigued.

"We don't know how much sustained exposure of this type will result in a permanent hearing loss," he says. "We do know that some individuals working in a noisy factory can lose hearing in a short time. Many artillerymen show hearing loss, even the two-year men. Some individuals can develop a loss in just one shot if they get too close to the gun."

Dr. Singleton and his associates found the greatest amount of noise was picked up in front of the band, as might be expected. The significance here is that most of the swingers like to spend the evening near the bandstand.

From a peak of 120 decibels at the bandstand, the noise level



dropped to only 106 decibels at the center of the dance floor. It remained high because the sounds reverberated off the draperies. Amplifiers also served to boom out the sound to distant points.

As a professional and a father, Dr. Singleton hopes to be able to determine what noise level will still be pleasurable for the rock fans and yet not be harmful. "We think 90 decibels is a safe level," he said, "and even peaks somewhat above that may not be harmful for a short period."

The research has yielded one important measuring rod for determining when decibels have risen to a dangerous point—when the "clothing of the chaperones begins to vibrate (at about 100 decibels)."

Infant victims of 'whiplash'

Infants found mysteriously dead in bed by distraught parents may be victims of a self-induced "whiplash." This clue in the age-old puzzle of sudden crib deaths was developed by Dr. Abraham Towbin of Boston University School of Medicine. He found hemorrhaging in the spinal column at the neck region in eight of nine such infants examined in autopsies. The hemorrhage indicated to him a snap-in-jury had occurred to the spinal cord, followed by a suppression of the spinal cord's nerve function. This can happen to a baby put to bed in an apparently healthy condition the night before.

Dr. Towbin points out that an infant's head is large and heavy, making up about a fourth of the body weight. "Structurally," he explains, "the young infant is top heavy. The head is four times as heavy as an adult head in proportion to weight."

The heavy head, pivoting atop the unstable spine, leaves the infant vulnerable to self-injury. Mothers instinctively support a baby's head when carrying him about.

Between 12,000 and 25,000 crib deaths occur each year in the United States. Doctors have been completely baffled by them. They have variously blamed suffocation, overwhelming infection, pneumonia, allergy, adrenal insufficiency and other causes. Absence of proof has left anguished parents with no satisfactory explanation. Many blame themselves for neglect and carelessness.

Dr. Towbin's attention was drawn to the spinal column by noting the frequent occurrence of spinal injury in the death of newborn infants. Such injury is related at times to the forceful maneuvers required for delivery, but at other times it appears in apparently normal delivery.

Virus linked to diabetes

A virus has been found to be capable of causing diabetes in mice. It is a type found occasionally in the human digestive tract and is called the encephalomyocarditis or EMC virus.

Injected into mice, the EMC virus damages the islets of Langerhans, the portion of the pancreas that produces insulin. A failure to produce sufficient insulin is characteristic of diabetes.

Dr. J. E. Craighead of Boston found about 40 percent of the infected mice developed high sugar levels, among other signs, indicative of diabetes. Why some mice became diabetic and others did not is still to be determined. Some of the animals recovered from their diabetic symptoms, but continued to show loss in ability to handle sugar metabolism in a normal fashion.

Why kids take drugs

The decline in LSD use shows that young people can be reached through information, a Yale University scientist contends. He says efforts to deter them by punishment are hopeless.

Young people use drugs as a

way of searching for "meaningful contact" with the world, Dr. Kenneth Keniston told a conference sponsored by the American Medical Association. They have grown up in a world that has known do-

mestic strife, constant violence and the threat of annihilation.

"The young become alienated from the wider society when they find in it little integrity, little idealism, few sources of pride and satisfaction," Dr. Keniston points out. "When this happens, they turn away from the traditional rewards of society to try to find some other world in which meaning and fulfillment can be achieved. Some turn to drugs to find the tranquility. Whatever we think of the dangers of this quest, it is not altogether different from the hopes with which adults approach alcohol."

Keniston contends it is wrong to assume that experimentation with drugs leads to drug abuse.

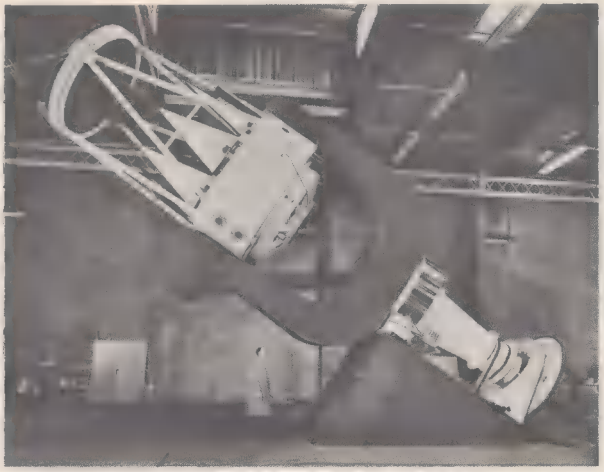
"The drug of preference today is, of course, marihuana," he says. "A number of surveys of drug use on the campus show that the majority of students using marihuana do so only occasionally and have not organized their lives around it."

If society is alarmed by the method youth has chosen to search for meaning, it should not condemn, but rather demonstrate by example that there are better ways. He called for programs of drug education beginning in the secondary schools and continuing through college.

AMA's facts about medical folklore

Much medical folklore is forgotten today, but a number of erroneous beliefs do still persist about health. Some of the common misconceptions listed in "Today's Health," the American Medical Association's health information manual, include:

- Eating between meals is always harmful. *(Not true.)*
- Bad breath means disease. *(No.)*
- Milk should not be drunk at the same time sour fruits are eaten. *(This is not true.)*
- Daily bowel movements are necessary for good health. *(False.)*
- A laxative is good for abdominal pain. *(It is sometimes dangerous.)*
- Food kept in an open tin can becomes poisonous. *(Not if it is properly refrigerated.)*
- Boric acid strengthens the eyes. *(It does not).*
- A cold can be broken up or cured. *(No, it cannot).*
- One should feed a cold and starve a fever. *(No.)*
- Eye muscle exercises will eliminate the need for glasses. *(No, this is definitely not true.)*
- Vegetarianism is good for health. *(No, it merely makes good nutrition more difficult.)*



Giant 90-inch telescope weighs 100 tons and belongs to the University of Arizona's Steward Observatory on Kitt Peak. When put into operation this year, it will be the fourth largest in the United States; sixth largest in the world. By Boller & Chivens Division of Perkin-Elmer Corp. and L & F Machine Co.

Predicting earthquakes

GEORGE E. ROUSE, a young *Colorado School of Mines* geochemist, has developed a theory which may lead to a global-earthquake prediction system, give clues to hidden mineral deposits and explain how interplanetary magnetism helps create the earthquakes, mountains, valleys and volcanoes.

The theory grew from Rouse's observation that major earthquake zones of the world lie on circles crossing the surface of the globe. These zones, he later found, correlate directly with maps of the earth's magnetic field, gravitational variation and major mineral deposits.

Earth scientists have known for many years that earthquake zones, mountain chains, ocean ridges and island chains fall in curved lines on the earth's surface. But they have never been able to explain why.

These curves, called "Benioff zones," are scattered all over the planet. What Rouse did was to treat them as the edge of planes. When he projected the planes completely through the earth, two things became evident. One was that every plane was tangent to the outer core

Discoveries vital to earthquake worldwide prediction have been made by Colorado geochemist George Rouse, with globe.

of the earth. The second discovery was that the planes emerged on the surface to coincide with the Benioff zones of other quake areas and with volcanic and other seismic areas. Only 16 quite narrow belts linked the major seismic features of the globe. Five more linked the areas of lesser activity. In addition, many major primary deposits of heavy metals of the world lie on the belts and their intersections.

Two other discoveries have followed. One is that a map of the strong and weak spots in the earth's magnetism bears a regular relationship to the planes which define the Rouse belts. The second is that a map of gravitational highs and lows has a relationship to the circles.

The explanation for this—still hypothetical—is that these magnetic and gravitational effects as well as the surface seismic features are all reflections of what is happening at the core of the earth. The theory is that the interplanetary magnetic fields which are being mapped by satellites cause the heavy iron core of the earth to try to rotate on a slightly different pole from the rest of the globe. Strains are then set up which reflect themselves in mixing of mantle and core materials creating surface irregularities.

Spreading outward, these strains lead to the surface readjustments we know as earthquakes.

City under glass

Man can settle in new areas of the world, now deserted because of weather extremes, if he can be protected by huge domes which would cover entire cities. This is the belief of Prof. Byron C. Bloomfield, director of the Environmental Research Center of the *University of Wisconsin*.

"Dome-covered cities," says the environmental researcher, "mean complete control of climate. Technically it is possible, but it will also demand biochemical adjustments of the citizen to new climate. Such adjustments, however, can be expected to be within the human adaptation range."

Engineers, architects and designers are involved in a scheme for a dome city which is being considered for upper Minnesota, an area in the U.S. known for severe winters.

Modern technologists say that

they can construct domes at least two miles in diameter and one mile in height. They estimate that such a dome can be built for about $2 a square foot, and the cost of a two-mile-diameter dome is estimated at $200 million. The maximum population for such a dome city would be around 250,000.

However, Prof. Bloomfield foresaw many problems for a domed community.

Insects—electronic wonders

Insects are like tiny satellites, scanning their small world with supersensitive electronic sensing devices.

P. S. Callahan, *University of Georgia* biophysicist, says their antennae are structured in mathematically precise configurations which respond to particular frequencies much like a TV antenna.

Callahan works at the U.S. Department of Agriculture Southern Grain Insect Research Laboratory in Georgia. His laboratory contains a bewildering array of devices such as oscilloscopes, miniaturized computers, electron scan microscopes and lasers. It looks more like an electronics research facility than an insect laboratory.

Insects detect odors through specialized cells on the antennae. It had been thought that these cells were structured so that molecules emitted by substances such as food sources and other insects fit into them like pegs into holes. Since molecules from each source have their own distinctive shape, insects would respond only to specified sources.

Callahan maintains that this is not the way it works. He says that insect antennae really are antennae in the literal sense of the word, responding to wavelengths like radio or television receivers. Using an electron scan microscope he recorded the special configuration of antennae, and was impressed by the mathematical arrays of spines similar to antennae built by man.

In general, Callahan says, the electronic sensing devices of insects appear to be far more sophisticated than suspected.

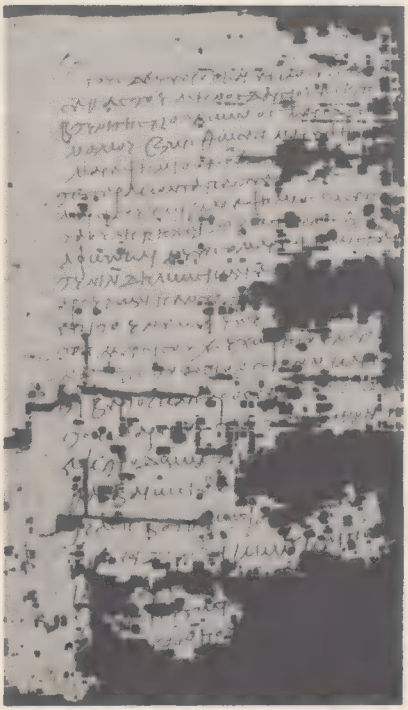
The end is near

Southern Californians may be rapidly approaching their limit tolerance for air pollution, and an early determination of that critical limit is imperative, declares Dr. Leslie A. Chambers of the *University of Southern California*. Dr. Chambers is head of a five year study of the effects of air pollution on animals.

The study has indicated that it is useless to consider air pollution dangers alone without taking into account other stressful conditions—freeway driving, noise and other complexities of living together in such cities as Los Angeles, Dr. Chambers said.

ARCHAEOLOGY

Looking for a job? Try papyrology



This ant-riddled papyrus document is the remainder of a land lease dating back to 36 A.D., the 22nd year reign of Emperor Tiberius Caesar Augustus in Egypt. Papyrologists have translated it as saying: "Marepsemis, son of Marepsemis, Persian, about 40 years old, has leased to Marsisuchus, son of Marepsemis, about 50 and marked with a scar on his right forearm—arouras of public land. Marepsemis has received rent in advance and guarantees this lease 'with every guarantee from all public and private charges.'"

WHAT was life like among the Greeks 2,000 years ago? What type of books did they read? How did their legal documents compare to ours today? What exotic foods did their grocery lists call for? The questions are endless, but so are the answers, if enough scholars can be trained to probe the faded handwriting on ancient papyrus texts for the answers.

Papyrus, the paper-like material made from the plant of the same name, was widely used by the Greeks beginning some 2,300 years ago (and 27 centuries before that by the Egyptians). With the introduction of paper to the western world in the 8th century A.D. began the decline of the use of papyrus. The plant itself is now almost extinct, although it was once quite plentiful in Egypt and other Mediterranean countries.

The problem today, though, is not the extinction of the papyrus plant, but rather the abundance of the ancient texts and the lack of papyrologists, scholars who are trained to decipher them. There are enough untranslated papyrus texts to keep dozens of papyrologists busy for years. And more are constantly being discovered. But there aren't dozens of papyrologists around.

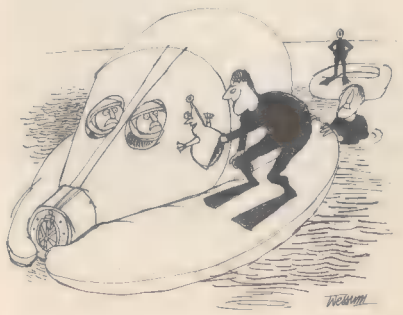
There are probably less than 10 active scholars in the United States, with only one or two of them devoting full time to studying the ancient writings. Few universities offer courses in the science, and "how to" books for self-instruction are relatively rare.

But the American Society of Papyrologists has taken steps to alleviate this shortage. This past summer they sponsored, for the second year, a Summer Institute in Papyrology which was held at Princeton University. There graduate students in classics spent a great deal of time studying how to decipher and translate the ancient Graeco-Roman writings and then putting that knowledge to practical use.

The books they studied fell into two categories—literary works and documents. Portions of the writings of the historian Thucydides and the philosopher Plato made up a segment of the literary group. The documents—tax receipts, land sale records, grocery lists—were pieces of prose obviously not written with posterity in mind, but interesting nonetheless. All such pieces of papyri offer a peek at the past and some of the aspects of the common people's everyday lives. Both the literature and documents have one thing in common. They're all rather small, and very old, scraps of brown paper-like material. Some are in such bad condition that they are crumbling to small pieces, and they come complete with a generous sprinkling of ant holes throughout.

The very poor condition of the ancient works is only one of the difficulties in bringing this past into the present, though. The language of the common people, which is largely used in the documents, is idiomatic and ungrammatical—not like the classical Greek learned by the scholars. And the penmanship of the writers leaves a great deal to be desired. They weren't too considerate of their readers, either, for they wrote in one unbroken line, leaving the reader the happy chore of supplying the appropriate breaks between words. They also used no punctuation.

Hopefully the American Society of Papyrologists will be successful in its efforts to revive this profession, currently one of the least populous in the world. It would indeed be a pity for this very close touch with the ancient world to become a lost art in today's modern world.



TECHNOLOGY

Life aboard a Polaris

by Creighton Peet

"Rig for diving" blares the PA system. Signals in the control center show all hull openings sealed. The 136 men aboard this plump 400-foot Polaris submarine know that for the next 60 days they will not see sun, stars or anything else outside.

Crew and ship have become one formidable and fearsome weapon. For two months the men will live with 16 huge Polaris missiles equipped with nuclear warheads. If the order ever comes from the White House, they will fire those missiles at one minute intervals, up through the ocean and into the stratosphere. The result would change forever the world as we know it.

Understanding this—and these men do understand—could be terrifying. But as one man put it, "Familiarity breeds acceptance." Submarine and missiles are real, and so is the job—all part of a deterrent force which the world hopes will preserve a nuclear peace. "Deterrent" is the word that gives comfort.

From a human, day-to-day, hour-to-hour point of view, a more expedient question becomes: How does a man keep from going "stir crazy" in cramped quarters under the ocean, living with the same men day after day for weeks on end?

To find out, I went on a brief patrol with these submariners, and talked with many others on the beach who had served on long Polaris missions.

The Navy is extremely selective in picking Polaris crews. No matter how skilled a man may be at his specialty, if he's inclined to grouse and make trouble, or if he's known to have a quick temper, he's not chosen.

On the positive side, any Polaris is roomy—even luxurious—compared to World War II subs. Bulkheads are no longer painted steel plates studded with rivets: Walls and partitions, often plastic-covered, are a variety of colors.

In the officer's mess, the walls are covered with a material which suggests walnut panels. The crew's bunks look like Pullman berths, with foam-rubber mattresses, individual reading lights, adjustable fresh-air vents and curtains for privacy. Usually bunks are stacked in tiers of three, but sometimes they are four deep.

And there's the food—chicken, steak, cakes, pies. Meals are served four times a day, to accommodate men coming off duty at odd hours. Menus are varied: chicken Isabella, baked Alaska, shrimp Newburg, beef Strogonoff, lasagna. There are occasional pizzas, curries and big batches of fudge run up late in the evening.

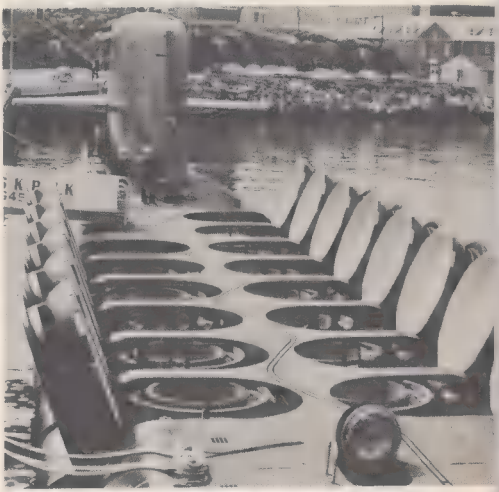
submarine

For in-between snacks there are help-yourself malted milk mixers, a soft ice cream machine, a popcorn popper, a coke machine, an ice cube maker and a coinless jukebox if you want a little music. And every day there's a different movie, usually shown two or three times to accommodate all watches.

Duty hours are shifted continually, but usually a man works four hours, then has six off. The big question is, how does a man occupy himself during his free time for 60 days? Most crewmen devote long hours studying for advanced ratings, working from books in the ship's library. In time he takes written and oral examinations given by the officers. Ashore, back at Groton at the end of a patrol, he can attend lectures by Harvard professors in the "Polaris University," where credits earned can count toward a degree.

Polarismen, like all submariners, are double volunteers: They volunteered to get in the Navy, and volunteered again for submarine service. Nearly all enlisted men are under 25; officers are under 35. They are the pick of the Navy, and their training is so extensive they have had to sign up for six years.

For a few days just being on a Polaris submarine is exciting. Then a man realizes he can't even write a letter home. Radio silence is imposed. Any transmission quickly



Top: The Polaris submarine Will Rogers submerges. Crewmen must prepare to spend 60 days underwater. **Above:** Polaris sub with hatches open disclosing firing tubes for the sixteen nuclear-tipped missiles. The missiles could change the world, but crewmen accept them as routine.

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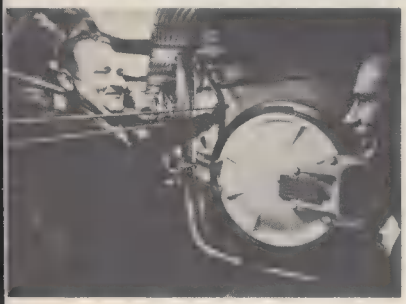

reveals a ship's position, and the Navy boasts that no Polaris submarine has ever been spotted once it submerged on patrol. However, the ship *receives* radio broadcasts once a day when she comes near the surface, trailing a fine, floating aerial wire, invisible to inquisitive planes. And once a day the teletype in the radio room begins to chatter with routine messages from the Navy, news bulletins and "familygrams" for the men—15 word messages from home. In two months a man can receive three or four such messages. But no matter what he hears—a new baby or a death in the family—he can't answer a word.

In case of emergency, a submarine can be reached at any moment via transmissions of very low frequency radio waves from special transmitters in the U.S., and other points around the globe. These will reach a submarine at any depth.

The men have all the standard games: checkers, chess, bridge, poker, etc. Bingo gets a special treatment on some ships with a fancy dinner and decorations on Casino Night. As for the movies, not all men are happy about them. Producers simply don't make enough good ones to last through a 60-day patrol.

Minor occasions are blown into big events. A man has a birthday, and the cooks bake him a cake. At Christmas somebody gets into a Santa Claus suit and hands out presents. At Easter on some ships an Easter Bunny appears wearing a shiny decontamination suit and a

3

1. Bunks of the Polaris subs are the Pullman type. Old navy standby, the hammock, is gone. 2. Crewmen display entries in sub's paper airplane contest. 3. Flying space on a sub is limited, even for a paper plane. 4. Exercise is needed to work off all those heavy meals. 5. Facilities are not spacious, but compared to World War II subs, they are luxurious. 6. Practically anything is reason for a fancy dress dinner aboard the sub.

6

big wad of cotton for a tail.

On the *SS Robert E. Lee,* a paper airplane contest was held last year. It was a great success. Some men work with electronic gear or woodworking tools. One officer does scrimshaw work similar to that done by last century's whaling captains.

Weirdest contest on the *Robert E. Lee* is a "snuffy race." Contestants wear skin-tight EBA (emergency breathing apparatus) head masks and race an intricate course through the ship, and up and down ladders between the three decks. The trick is to make the oxygen in the mask carry a man as far as possible before he drops. At many places in the ship there are valves into which a man can plug his mask to gulp in a lungful of oxygen. But the more often he stops, the further behind he gets in the race.

Biggest event on patrol is the midway dinner, after about 30 days. The men sit down to a meal served on real linen table cloths, by candlelight. "Makes it kind of homey," an officer explains. Sometimes men will get into what might be called psychological wrestling matches. "You try to make a man break," they told me. "You say, 'I can get you!,' and you study a man's personal appearance, habits, weaknesses. You tell him his wife is going out with somebody else . . . he's going to flunk his exams . . . he certainly has a funny face, etc."

Do they ever have fights? The men swear it never happens. When a fight seems likely, men walk away from each other and stay away until they have cooled off. At least

that's what they say.

Of course there's one thing these young fellows miss which the Navy can do nothing about. "What we need," said one cook thoughtfully as he dumped a package of cake mix into a beating bowl, "is Instant Woman: just mix with water and . . ."

Something for the Navy to work on.

In addition to the usual housekeeping chores, there are some that are unique to submarines. Garbage disposal, for example, is a big deal. It is essential that nothing disposed of float or leave any trace on the surface of the sea. Using flat sheets of metal, galley hands form a cylinder about three feet high and 10 inches in diameter. This slides into a hydraulic press. After it is filled with garbage, tin cans, bottles, paper, etc., a hydraulic ram compresses everything with a satisfying cr-r-r-unch until it is a solid block. Then an inch-thick iron disc is added for weight; the top is fastened, it is heaved into an ejection tube and fired out into the sea where it sinks to the bottom.

Operational headquarters is in the control center where the periscopes are located. To steer the newer Polaris submarines, men sit in front of fantastic gadgets known as "Conalogs," which look like a pair of 19-inch TV screens. On the screens, they see a computer-produced picture of what appears to be a wide concrete superhighway reaching off to a vanishing point. Painted in the center of the screen is a small red cross. By holding the half-wheel (similar to an aircraft control stick) so that the vanishing point and the cross coincide, a man steers straight ahead. If he pulls the wheel up or pushes it down, the ship heads up or down in the water. When he turns to the right or left, the "concrete roadway" miraculously curves right or left, and stays curved until the helmsman straightens his course. One of the two Conalog screens reacts to the movement of the ship's bow planes; the other, the stern planes and rudder. Between the screens is a depth indicator. It looks a little like a taxi meter clock.

'Sherwood Forest' of missiles

Also down in the control center are the computers that control the firing of missiles. One vital panel reports the status of all openings in the hull. A large black circle on this lighted panel indicates a hatch is open. When the circle changes to a bar, it is closed. Usually, about eight to 10 men work in the control center together.

The locked compartment enclosing the big Polaris firing tubes—each 31 feet high and four-and-a-half feet in diameter—is known as "Sherwood Forest." Here a dozen or so specialists work every day checking and rechecking every system involving the missiles.

Also locked and seldom visited are the compartments containing the nuclear reactors that furnish power to drive the submarine and

The nuclear missiles themselves are kept in a locked compartment that few are able to visit.

all its equipment.

No matter how hot or cold it is on the surface, the climate way down deep is always comfortable. And the air is pure. After producing 8,000 gallons of pure drinking water a day from sea water, some is split into its basic oxygen and hydrogen. The first is fed continuously into the ship's ventilating system, while the hydrogen is pumped back into the sea. Submarines boast their ships are about the healthiest places you can be. A couple of days after a patrol starts nobody even has a cold.

Thirty-four of our 41 Polaris subs (with a total of 656 missiles), are assigned to the Atlantic. The rest are in the Pacific. But while the Atlantic Flotilla's home base is Groton, Conn., few of the subs ever see this port. They are based at Holy Loch, Scotland, and Rota, Spain, where their tenders tie up to take on supplies. Most often they make contact with their tenders at sea.

With no daylight and a round-the-clock schedule during which some men are always sleeping, it would be easy for a man to lose track of night and day. So certain areas in the ship are "rigged for red" at night—indicated by dull red lights.

Dress is informal at sea. Not even officers wear uniforms. Crewmen wear "poopy suits" of dark blue Dacron resembling an auto mechanic's coveralls. However, these are closed with strips of an adhesive that's fastened to the cloth. Zippers might prove dangerous if a man leaned against a panel covered with electrical equipment.

Many months under is possible

While crews know that in peacetime they will be submerged for about 60 days at a time, they also know that some nuclear submarines have been down much longer. Back in 1959 the *Triton* circumnavigated the globe in 83 days without surfacing. The reactors which power a Polaris will function for three or four years. Limiting factors are the food supply and the men's capacity to tolerate long confinement. *Triton* carried food for 120 days, and even on a conventional Polaris patrol, every cubic inch of space is packed with cans, cartons and bottles of food. Except for its occasional contact with a tender, a ship might conceivably stay submerged for many months. In the case of a war, this would be academic. After a Polaris had fired her 16 missiles, plus the few regular torpedoes she carries for self-defense, and the men had eaten their last frozen steaks, she would be forced to locate a submarine tender in a safe port. That is, assuming there was a "safe" port left.

Idea of the Month

The atomic watch

CORPORATE management usually leaves invention to the research engineers, but two directors of the Benrus Watch Company are unorthodox in this respect. They were recently granted a patent for an atomic watch.

The timepiece is to mark the hours and minutes by electronic measurement of the decay of a harmless radioactive substance in the case. For the timekeeping itself, no moving parts are required. The small battery that powers the electronic circuits can move the hands.

Julian Lazrus, president of the company; Lewis H. Strauss of Washington, a director; and William P. Canning, a former employee, received Patent 3,370,414. Strauss, a consulting physicist, is the son of Lewis L. Strauss, former chairman of the Atomic Energy Commission.

Certain radioactive materials with constant decay rates (a long "half life") give off only beta rays, according to the patent. These rays are regarded as incapable of penetrating a watch case or even the skin of a wearer's wrist.

Technetium 99 is one element suggested. It has a half life of 500,000 years, and would cost about a cent per watch. Another material is boron 10, whose half life is put at 2,700,000 years. A half life of 10,000 years is regarded as a minimum.

Lazrus calls the invention a statistical timekeeper. It might be inaccurate on a one-second basis, but its errors are not cumulative, and on the long term its accuracy can be higher than with conventional watches.

The patent cites as example an atomic output of 20,000 pulses per second, with a probability of error no greater than 20 seconds per month.

The timepiece should have present uses at remote, unattended stations in space, according to Lazrus, but without miniaturization and development cannot reach the market as a watch for years. The company is preparing to launch much sooner an electronic watch with a quartz crystal oscillator. Japanese and Swiss makers have been developing similar watches. —*Stacy V. Jones*

U.P.I.

Why is gold so good?

by John and Molly Daugherty

THE search for gold continues, yet new gold veins are hard to find. Electronic devices detect unseen specks of gold so small they measure only a few microns. A micron is 40-millionths of an inch. This gold is scattered, but it still may be profitable to work.

Two major gold strikes have occurred in the past few years. One in Nevada may be worth $100 million. In 1967 the U.S., using new electronic equipment, made 150,000 samplings of soil for gold and other metals.

What do you know about gold?

1. At $35 an ounce for gold, a shoe box filled with two bars of gold is worth
   a. $28,000
   b. $ 8,000
   c. $58,000

2. Gold melts at 1,063° C. and boils at 2,600° C. At temperatures above the melting point, gold volatilizes. At the boiling point the color of vaporized gold is
   a. Yellow
   b. White
   c. Purple

3. World production of gold (excluding U.S.S.R. and other Eastern nations) amounts to about $1,450 million. The leading area is
   a. The United States
   b. South Africa
   c. Canada

4. The most important chemical process for the recovery of gold from ores is
   a. Amalgamation
   b. Chlorination
   c. Cyanidation

5. Early in the 20th century, 72 dredges recovering gold operated in California. After World War I only a few remained. One operation was unique. It carried its pond of water with it across the country. It was
   a. Paddock dredging
   b. Hydraulic mining
   c. Bucket-line dredging

6. Recently the state leading in U.S. gold production for the 18th consecutive year was
   a. California
   b. South Dakota
   c. Nevada

7. Gold is
   a. The most malleable metal
   b. Second to silver in ductility
   c. Less dense than silver and lead

8. Today most of our gold comes from
   a. Stream-deposited (alluvial) gold
   b. Hard-rock (lode) mining
   c. Sea-water recovery

9. Dental gold is
   a. Pure gold of mint quality
   b. About 50 percent gold
   c. From 65 to 90 percent gold

10. Gold may form an explosive compound, fulminating gold, when concentrated ammonia reacts with
   a. Melted gold
   b. Gold oxide (auric)
   c. Solid gold

Answers:

1 - a $28,000. Each bar is worth $14,000. Wooden boxes about the size of shoe boxes carry gold from the Rand Refinery in South Africa to the Reserve Bank and from there to London and world commerce.

2 - c Purple. The amount of gold lost in vaporizing is slight at temperatures just above the melting point. At mints, workers melt gold and cast it into thick plates before electrolytic refining. They periodically sweep the flues above the gold pots to recover the gold lost in vaporizing.

When pure gold is plated out in the expensive three- or four-day electrolytic operation, the platinum recovered may pay for the job.

3 - b South Africa. South African gold production has a value of about $1,080 million—more than two-thirds of the world's output. Canada ranks second with $115 million, and the U.S. ranks third with about $63 million.

4 - c Cyanidation. A weak solution of sodium cyanide reacts with gold in the crushed ore to form a gold cyanide. Zinc precipitates the gold from solution. When melted down, the recovered gold needs further refining by electrolytic processes to separate other metals, especially silver, from the gold.

The chlorination process, developed in Australia, separates the gold and silver common to most ores. When chlorine bubbles through the melted gold and silver, silver chloride forms. It floats to the top, leaving

the gold at the bottom.

There hasn't been much use of amalgamation since 1850.

5 - a Paddock dredging. This dredge floated on a pond—natural or man-made. As dredging proceeded ahead in one direction, the debris filled in behind the dredge in the opposite direction. The waste products filling in at the rear pushed the water on ahead of the dredge. The paddock dredges could move uphill with the pond, too, by building a gravel embankment around the pond.

California restricted hydraulic mining under pressure as early as 1880 because waste products loaded up the streams below the workings.

6 - b South Dakota. It produces about 650,000 troy ounces a year. The largest gold mine in the U.S., the Homestake Mine, is in South Dakota.

California once led all the states. In 1940, California gold production was nearly three times that of South Dakota and twice that of Alaska. Since about 1950, however, production in California and Alaska has declined greatly.

7 - a The most malleable metal. Gold beaters can hammer it into sheets so thin (about 4-millionths of an inch thick) that the piece will transmit light.

Gold is also the most ductile of the metals. One ounce of it can be drawn into wire 35 miles long.

Gold has a density of 19.3 (gm/cu.cm); silver, 10.5; and lead, 11.3. In comparison, water has a density of 1 gm/cu.cm.

8 - b Hard-rock (lode) mining. Since 1920, alluvial deposits have become less important than formerly. The largest mass of gold, the Holtermann Nugget, found at Hill End, New South Wales, had a weight of 7,560 ounces, gross, and 3,000 ounces, net. Sea-water recovery isn't profitable yet.

9 - c From 65 to 90 percent gold. The silver content of the alloy ranges from 5 to 12 percent. Frequently platinum and sometimes palladium are included. Since pure gold is so soft, iridium may be used in small amounts for hardening. Dental gold has many different analyses.

Gold foil of 2 percent copper and 98 percent gold may be used for fillings. The copper adds hardness to the alloy. The amounts of copper in dental alloys vary.

10 - b Gold oxide (auric). When this man-made oxide reacts with the concentrated ammonia, $2\ AuN \cdot NH_3 \cdot 3H_2O$ forms. When dried, the black powder called fulminating gold is the product. This powerful explosive detonates by friction or heating.

Score yourself:

9 - 10 right—Your market in gold is high.

4 - 8 right—All is not gold that glitters.

0 - 3 right—You were speculating!

Each month Dr. Isaac Asimov chooses one of the questions you send in to answer. He does not make the job easy on himself, for in past months he has written about such things as relativity, parity and the basic nature of light. Following Dr. Asimov's answer are the answers to some of your other questions written by regular members of the Science Digest staff.

'The scientific method'

What is "the scientific method"?

Obviously the scientific method is the method used by scientists in making scientific discoveries. This doesn't seem to be a helpful definition, however. Can we go into detail?

Well, one can describe an ideal version of the method:

1. Recognize that a problem exists—as, for instance, the question of why objects move as they do, speeding up under some conditions, slowing down under others.

2. Sort out and discard the nonessential aspects of the problem. For instance, the smell of an object plays no part in its motion.

3. Gather all the data you can find that bears on the problem. In ancient and medieval times, this merely meant the keen observation of nature as it existed. In early modern times, the notion arose that nature could be helped out. One could deliberately design a situation in which objects would be made to behave in such a way as to yield data bearing on the problem. One could deliberately roll balls down inclined planes, varying the size of the balls, the nature of their surface, the inclination of the plane and so on. Such deliberately-designed situations are experiments and the role of experiment is so central to modern science that it is sometimes spoken of as "experimental science" to distinguish it from the science of the ancient Greeks.

4. With all the data gathered, work up some tentative generalization that describes it all as simply as possible—some short statement or some mathematical relationship. This is an hypothesis.

5. With the hypothesis in hand,

you can predict the results of experiments you had not thought to try earlier. Try them and see whether the hypothesis holds up.

6. If the experiments work as expected, the hypothesis is strengthened and may attain the status of a theory or even a "natural law."

No theory or natural law is final, of course. The process repeats and repeats. New data, new observations, new experiments are continually being made. Old natural laws are constantly being superseded by more general ones that will explain everything the old one explained, and more.

All this, as I say, is an *ideal* version of the scientific method. In actual practice, scientists need not go through it like a set of calisthenic exercises, and usually don't.

More than anything else, such factors as intuition, insight and just plain luck, play a part. The history of science is full of cases of scientists who make a sudden inspired guess based on very inadequate data and on little or no experimentation and come upon a helpful truth that might have taken years to attain by straightforward slogging through the ideal scientific method.

Kekulé caught the structure of benzene while dozing on a bus. Loewi awoke in the middle of the night with the answer to the problem of synapse conduction. Glaser was glancing idly at his glass of beer and got the idea for the bubble chamber.

Does that mean that it's all luck, after all, and no brains? No, no, a thousand times no. This kind of "luck" happens only to the *best* brains; only to those whose "intuition" is the reward of great experience, deep understanding and hard thought. —*Isaac Asimov*

How high can a bird fly?

In 1921, Dr. A.F.R. Wollaston, a member of a British Mt. Everest Expedition, spotted a lammergeyer, or bearded vulture, soaring at 25,000 feet. This is generally considered the highest reliable sighting of a bird in flight. There is a photograph of geese an estimated 29,000 feet in the air, but most ornithologists no longer consider this claim accurate.

The lammergeyer is a large bird with a wing spread of over nine feet, but much smaller birds have reached remarkable altitudes, according to John K. Terres in his new book on bird flight, "Flashing Wings."

The record for North American birds is held by an unfortunate Mallard duck which collided with an airliner flying at an altitude of 21,000 feet on July 19, 1962.

An airplane flying over the Andes struck a condor at 17,000 feet, almost three miles above sea level.

Says Terres, "Most of the world's greatest altitude records for birds have come from the high Alps and Himalayas during the spring and autumn migrations of European and Asiatic birds. Goodwits and curlews — long-winged, swift-flying 'wading' birds or shorebirds—have been seen flying past Mt. Everest at 20,000 feet. Storks and cranes were sighted passing over the Himalayas at 14,000 to 20,000 feet and British Army Colonel Richard Meinertzhagen saw choughs (crowlike birds) at 21,000 feet above sea level, and a wall creeper over Karakorum at that height."

I have heard that twins placed in different rooms have registered the same type of brain waves and that this somehow supports the existence of ESP.

A few years ago in Philadelphia, a pair of researchers were studying the brain waves of identical twins. In one case they found that when one of the twins closed his eyes, the electroencephalograph registered a pattern called alpha waves, a common pattern when an individual closes his eyes and relaxes.

But to their surprise, the researchers found that the subject's twin, in another room, also began registering alpha waves at about the same time, although he did not close his eyes. There was no known way by which an individual could consciously produce alpha waves, and so the researchers concluded that one twin must somehow have been transmitting his alpha wave pattern to the other.

When the Philadelphia scientists published their results, they were unaware that experiments had already been conducted that proved that individuals can consciously control the production of alpha waves.

Joseph Kamiya, one of the pioneers in sleep research, had become fascinated by the alpha rhythm.

He found that many people could rapidly be trained to control these waves.

"People describe themselves as being tranquil, calm and alert when they are in the alpha state, and about half of our subjects report the alpha state as very pleasant," he writes in *Psychology Today*.

To Kamiya, the reports of his subjects sounded like descriptions of states of Zen and Yoga meditation, and he invited seven practiced Zen meditators into his laboratory. He found they could control their alpha waves far more quickly than the average person.

Aware of the great interest in ESP, Kamiya warns, "It must be stressed that there is no connection between alpha waves and extrasensory perception. People tend to associate the two because radio waves are involved in communication. . .the amount of energy involved is so infinitesimal that a powerful receiver placed half an inch from the skull could never detect it. There is no evidence of electromagnetic radiation to the outside world by brain activity."

What are we fighting about?

War—The Anthropology of Armed Conflict and Aggression. Edited by Morton Fried, Marvin Harris and Robert Murphy. The Natural History Press. ($6.95).

Anthropologists are popularly thought of as those scientists who study the ways of primitive "nature folk"—tribes stuck on isolated islands, or in the middle of steaming jungles. The trouble is that such "primitives" hardly exist anymore. Many of the "tribal" peoples studied by anthropologists are in "colonial, refugee, peasant and other non-primitive situations," according to the editors of this most unusual anthropological work.

With refreshing frankness, the editors state that many anthropologists have been frantically searching for "primitives" to study, and if the genuine article did not exist they have been, "subtly encouraged to present their data as if the larger world of colonial wars, labor recruitment, taxation, indirect rule, forced migration, missionization and other post-contact phenomena did not exist."

So the anthropologist continued to study the "primitive" even when his studies were meaningless. But as anyone who has seen a newspaper within the past two years must surely know, the war in Vietnam has caused a virtual explosion of conscience within the academic community.

At the 66th annual meeting of the American Anthropological Association, a lengthy symposium was held, not on the customs of the tribes of the upper Amazon, but on modern war. This book is a record of the symposium.

Like all transcribed symposiums, "War" makes somewhat uneven reading. There are eight main subjects, each covered by one major and one secondary paper, and then subject to general discussion. Naturally there is a good deal of wandering away from the main points, and a good deal of repetition. But the intellectual novelty and stimulation of looking at the problem of war from so many different and unusual angles amply rewards the reader who will stay with it through rather lumpy organization of this book, and the jargon of some of the anthropologists.

One particularly interesting part of the symposium was the discussion of human aggression by Ralph Holloway. In recent years certain scientists and science popularizers have advanced the theory that man, because of his biological evolution, is innately and hopelessly aggressive. Strangely, many who care little for science have hugged this rather grim theory to their breasts as both comforting and true. For if it is all "instinct," then one is excused from the moral responsibility of all aggressive acts, and from the intellectual responsibility

of questioning our societies' basic attitude toward war.

Holloway finds the "animal aggression" idea both incorrect and dangerous. Animal studies are valuable, but to try and draw a direct correlation between aggressive behavior in baboons and modern warfare is just too simple-minded, he says. "It is power, organizations, socio-economic conditions and symbol systems that need study," he concludes.

Frank Livingstone contended that warfare has a negligible biological effect on large populations. No matter how great the slaughter, he points out, the populations have always bounced back rapidly.

Other participants disagreed. Alexander Alland, in his paper on War and Disease, raised the specter of plague in Vietnam.

"The U.S. military can easily vaccinate its soldiers and a good part of the urban population, but what of the civilian village population, particularly in uncontrolled territory? According to Vietnam government statistics, only about a quarter of South Vietnam's population has been immunized with plague vaccine."

Alland also makes a serious charge. "I submit that the kind of conventional warfare that has been raging for the past three years is, intentionally or not, kind of covert biological warfare. The continued imposition of stress conditions upon an area with a delicate health balance will, in a variety of direct and indirect ways . . . subject the inhabitants to the same type, if not the same degree, of pathological devastation as that brought about by overt action involving biological and chemical agents."

Agree or disagree, the anthropologists have provided a look at war from points beyond the political and military. There are no answers, no conclusions and very few general agreements—but the book does jar the conventional stereotypes of thought about war.—*D.C.*

Other new books of interest

Water Treatment (Second Edition). Eskel Nordell. Reinhold. ($14.00). This volume is the answer to many letters in the *Science Digest* mailbag recently regarding problems of pollution in industry. First written in 1951, the comprehensive volume on "everything there is to know about water" was updated recently to include latest advancements in water treatment and their applications. It deals in methods of dissolution of minerals, gases, turbidity, sediment, organic matter, tastes, odors, etc. Methods of conditioning industrial and municipal supplies are spelled out in detail, as are systems for softening both cold and hot water. It's a 600-page opus, with charts and diagrams.

Man and the Cosmos. Ritchie Cald-

er. Frederick A. Praeger Publishers. ($5.50.) The book's subtitle, The Nature of Science Today, gives one an idea of the vast area covered here. It is written for the intelligent layman who wants to grasp some of the intricate details of the enormous world of science, and it has been written as a Britannica Perspective, to commemorate the 200th anniversary of *Encyclopedia Britannica.*

The World of the Ant. David F. Costello. Lippincott. ($5.95). Ants, the author says, are "among the least understood and appreciated of all small creatures," even though they have been around for one hundred million years. This is his contribution, complete with illustrations, to a better understanding of the small insect.

The German Atomic Bomb. David Irving. Simon & Schuster. ($6.95). Here is the little publicized story behind Nazi Germany's World War II efforts to build an atomic bomb, the personalities of the 10 main German scientists who worked on the project and the various reasons why their project failed while America's succeeded.

A Field Guide to Wildflowers. Roger Tory Peterson. Houghton Mifflin. ($4.95). Mr. Peterson offers another of his field guides—this time to wildflowers in northeastern and north central North America. He has arranged over 1,000 flowers by a visual system of identification. The book is divided into six main color sections, so the reader can readily find and identify the various wildflowers.

Weeds. Dorothy Childes Hogner. Crowell. ($3.95). This one is for the youngster who wants to learn the basic facts about the variety of plants that grow where they're not wanted and are sometimes quite harmful.

Animal Twilight. J. L. Cloudsley-Thompson. Dufour. ($6.95). The extinction of many of the world's animals has been brought about by man, and it is rapidly approaching for other animals unless some necessary steps are taken to prevent this tragedy from occurring. The history of man's impact on African animals, including actual accounts by hunters of their conquests and descriptions of some of the primitive and crude methods used for trapping by natives is as convincing a plea for conservation of wildlife as you are likely to find.

It's All Done With Mirrors. Irvin D. Gluck. Doubleday. ($4.95). Here is the book for just about everything the average person could possibly want to know about mirrors. Written by a physics instructor and practicing optometrist, the book discusses every aspect of the history of mirrors, their importance to mankind (in both fun and serious respects), and he throws in some experiments for the reader to do with the tricky reflectors.

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LETTERS TO SCIENCE DIGEST

Korean 'syllabary' questioned

With regard to the February '68 issue, page 38, "Oriental language machine," developed by RCA, what is this nonsense about a Korean "ideograph" alphabet?

Several centuries ago, Dan-Jeon, fourth king of the YI dynasty, ordered the six scholars (the "Saiyukshin") to compose an alphabet that would be purely Hankuk (Korean). This task was accomplished in about 1442, by the Western calendar.

Imagine stating that there are thousands of characters in the Korean "syllabary" when, in fact, there are only 24 letters in the Hangul (Korean) alphabet. I believe that Hangul is one of the two only alphabetical languages in Asia (Punjabi being the other.)

R. Lee Haler
University of Alberta

RCA's Reply

There is indeed an alphabet in the Korean language known as the Hangul. In North Korea this alphabet is used almost exclusively, however, some Chinese ideographs are still in use to identify proper names and special terms. In South Korea, on the other hand, there is a much wider use of Chinese ideographs in combination with the Hangul. In fact, the Ministry of Education, Republic of Korea, in 1957 established a list of 1,300 "limited characters" to be used for compiling textbooks.

In the interest of completeness, RCA has included in its machine vocabulary some 4,834 Chinese ideographs used in Korean languages. This includes the "limited character" list established by South Korea. It must be noted that many of these ideographs are common to all three languages; however, a study of all three languages was conducted independently and the final list combined.

Dana N. Nasuti
News & Information Service,
RCA

Dying saguaro theory

Science Digest for April '68, page 29, "Saguaro— a dying symbol," discusses various theories of the dying out of the saguaro, the giant Southwestern cactus. The article failed to mention a theory that has long impressed me, at least, as the most plausible of all: That the slaughter of predators—bobcats, coyotes and foxes—has, as it has elsewhere, caused a vast increase in the rodent population of the area, and that this in turn has resulted in excessive and fatal burrowing by rodents into the saguaros.

L. Sprague de Camp
Villanova, Pa.

Criminal rehabilitation in N.Y.

Governor Rockefeller has asked me to thank you for forwarding Steve

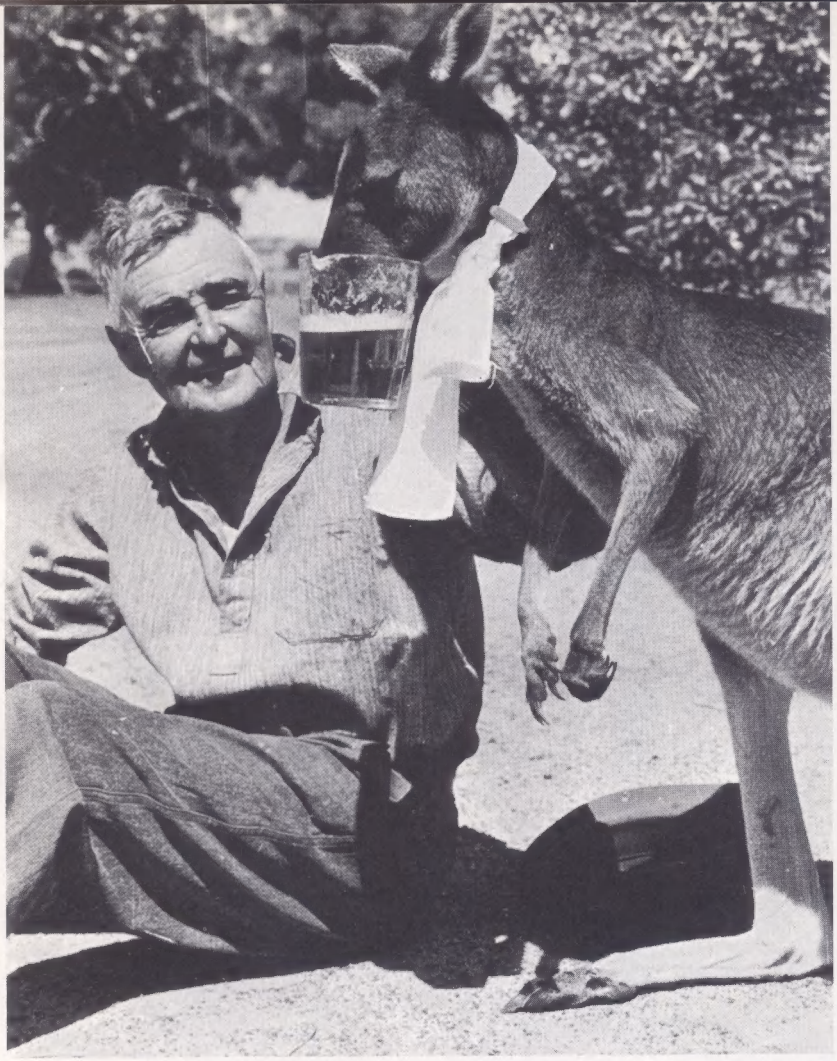
Allen's article, "Let's brainwash our criminals", concerning rehabilitation of criminals, which appeared in the April '68 *Science Digest*.

New York State already has in operation or under study many of the proposals suggested in the article, such as a pilot project using the latest techniques in psychology, psychiatry and education in realistic programs of rehabilitation, which is in its second year at Dannemora. This Diagnostic and Treatment Center, involving approximately 100 inmates, provides intensive treatment and social casework services for selected inmates transferred from other institutions of the Department of Correction.

The New York State Department of Correction is using in its 22 institutions other techniques such as: teaching machines and programmed instruction; remedial reading; videotapes and motion picture films; educational television. A number of service programs have also been initiated.

The concern of *Science Digest* in progressive correctional policy is deeply shared.

ALTON G. MARSHALL
Executive Officer to
the Governor



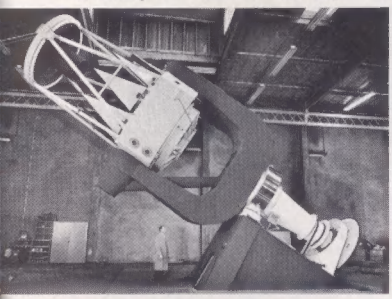
Pictorial Parade

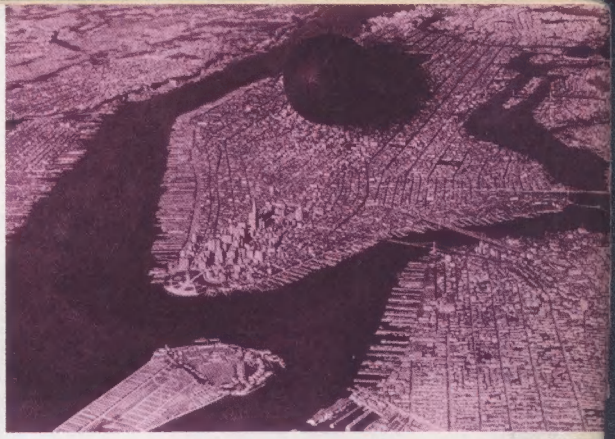
"'Ave another"

THERE'S nothing like a cold beer on a hot afternoon, and those are bloody well the sentiments of this very Australian kangaroo. When his owner introduced him to the brew, he developed an immediate liking. Now he usually partakes of a bottle and a half a day (no great amount by human standards, but something else when it comes to kangaroos, who normally don't even drink much water). This marsupial has one other notable habit—he likes cigarettes, but only to chew.

In this issue . . .

Not since the days of Galileo has the telescope been so important. Throughout the world the nations are rushing to build larger and better instruments. A new U.S. entry is a 90 incher to be installed at Kitt Peak, Arizona, for the University of Arizona. See page 71.





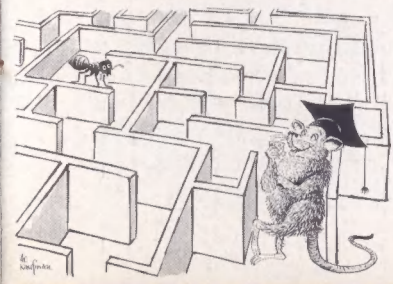
On June 15, a huge asteroid will pass fairly close to the earth. Only a small change in orbit could bring it crashing down. There have been many similar collisions in the past. When you think of it, our earth leads a pretty precarious existence. For a look at some of the dangers earth faces, see page 8.

The search for ways of improving efficiency and cutting costs on urban mass transportation is worldwide. In England the London Transport is testing a new "hands off" automatic control sytem for its trains. Trains are guided by coded impulses transmitted through the tracks. Details, page 64.

Driving a nail through a lightbulb without shattering it is a dramatic demonstration of a new kind of tougher, more durable bulb. It is one of the many products previewed in New for People. See page 28.

A new art contest was recently announced. The CalComp Awards Competition for computer/plotter art. This drawing called "The Fisherman," was one of the more striking examples of the new art form. See page 23.

Ants have a reputation for being very clever, but even a very stupid rat is smarter than the smartest ant. The truth is invertebrates just don't learn the way we mammals do. This has its advantages, however. For example, have you ever heard of a neurotic cockroach? See page 54 for a look at the ant's IQ.



The labyrinthodont was a subtropical amphibian that lived some 200 million years ago in Antarctica. The question is now: Where was Antarctica at that time? For further details, see page 16.